MOTIVATING RURAL FAMILIES TOWARDS IMPROVED FUEL MANAGEMENT PRACTICES

L. S. SATHYAVATHI

A THESIS SUBMITTED TO THE UNIVERSITY OF MADRAS
IN FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FEBRUARY, 1986

MOTIVATING RURAL FAMILIES TOWARDS IMPROVED FUEL MANAGEMENT PRACTICES

L.S. SATHYAVATHI

A THESIS SUBMITTED TO THE UNIVERSITY OF MADRAS
IN FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FEBRUARY, 1986

ACKNOWLEDGEMENT

The author records her reverential gratitude to Dr.(Tmt) Rajammal P.Devadas, M.A., M.Sc., Ph.D. (Ohio State), D.Sc., (Madras), Director and Dean of Post-graduate studies, Sri Avinashilingam Home Science College for Women, Coimbatore, for her deep insight, incessant guidance, valuable advice, scintillating interest and constant encouragement given throughout the course of the study. The author is highly indebted to her guide for the high motivation shown for the preparation of this manuscript.

The author places her deep sense of gratitude to Sri T.S.Avinashilingam, the Founder President of Sri Avinashilingam Education Trust Institutions for providing 'Saradalaya' the temple of learning, to carry out the research work.

The author is thankful to Dr.(Tmt.) Lakshmi Santa Rajagopal, M.S.(Tennessee), Ph.D.(Madras), Principal and Head of the Department of Family Resource Management, Sri Avinashilingam Home Science College for her valuable suggestions and encouragement given throughout the course of the study.

The author is grateful to Dr.(Miss.) S.Sithalakshmi, Ph.D.(Madras), Professor and Head of the Department of Extension Education, Sri Avinashilingam Home Science College, for her valuable suggestions in planning the programmes for field work.

The help and co-operation received from the Homemakers, Mahalir Manram Organisers and Science Club Members of the villages selected is gratefully acknowledged.

TABLE OF CONTENTS

CHAPTERS PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Food, fertilisers and fuel are the three national problems confronting India today. While concerted efforts have been made to meet the challenges of food and fertilisers, over a long period, the problem of fuel has come to lime light only recently, consequent to the world wide energy crisis. The problem,'energy crisis' requires the utmost efforts of the government, and the consumer.

The fossil fuel resources such as wood, coal, oil and natural and other gases are dwindling fast. (Fuel policy committee, 1972; Prakash, 1978; Ramalingam, 1978; and Sen, 1979). Hence it is absolutely necessary to break away from the practice of using conventional fossil fuels to meet all the energy requirements. The need of the hour is to base the economy on non conventional energy sources such as sun power and biogas, which are available everywhere.

The energy problem of the domestic sector is a complex one, with implications to the life of the community. Energy for domestic use is as essential and important as food and shelter for sustaining life (IAAS, 1983).

Procurement of fuel in adequate quantities necessary for the day-to-day cooking is one of the problems that every family faces as a result of the energy crisis. Shortage of electricity, inadequate production of cooking gas, difficulty in getting adequate quantities of kerosene, scarcity of firewood and their exhorbitantly spiralling prices have made every household struggle for energy and hope for a solution to this harrassing problem.

Since 80 per cent of India's population live in about 6,00,000 villages, India's energy problem should be studied in the context of the 80 per cent of the nation living in the rural sector. As the Father of the Nation, Mahatma Gandhi, had warned, 'If villages perish, India will perish too' (Parikh, 1978).

An analysis of the energy consumption indicates that fuel wood is the fourth largest source of energy coming next to petroleum products, coal and natural gas (Salariya, 1983). It is the principal fuel in the world and about half of the world's population uses this fuel to fulfil their energy requirements (Lokras and Kumar, 1983; Salariya and Jindal, 1983; and Tata Energy Research Institute, 1983).

Firewood has been the conventional source of energy meeting 87 per cent of the domestic fuel needs. The remaining 13 per cent are met by coal and kerosene. The problem of fuel wood is more menacing than is usually realised, and unless adequate measures are taken the fuel wood supply will be critical and unmanageable by the year

2000 AD. An additional 2000 millions or more will then be facing similar critical shortage within one or two decades and the future generation is bound to inherit a barren, polluted and dismal world (Prasad and Mandal, 1983). The shortage of fuel wood is associated with problems such as substitution of agricultural and animal wastes for firewood, labour requirements for obtaining fuel and large expenditure for purchasing fuel wood. Collection of firewood is becoming an increasingly arduous task for women and children who spend more than 2-3 hours per day per family walking even beyond 5 km per day (Bhatt and Reddy, 1982).

The availability of firewood for cooking is also taking a very serious turn. Seventy five per cent of the population, nearly 150 million people, fulfil 90 per cent of their energy requirement through wood. It is estimated that by the end of the century, 250 million more people will be unable to get firewood for their minimum requirement of cooking.

Another commonly used fuel in the rural households is animal dung in the form of dried cakes. Tam and Thanh (1983) quoted by Prasad et al state that 45 per cent of the domestic fuel requirements in the Indian Villages come from burning animal dung. It is estimated that over 30 per cent of 980 million tonnes of cattledung produced in India are burnt for fuel which could otherwise be used as organic manure. If the entire quantity of the cattledung produced is put through the biogas plants, the slurry can produce 36,260 million cubic metres of gas which will be adequate to meet for domestic fuel requirement of 87.45 million families (KVIC, 1984).

The energy crisis demands effective planning and use of the limited energy sources. Real management lies in using 'what we have, to get what we want' (Gross and Crandall, 1963). The available resources should be utilised to the fullest extent to solve the energy problem. Hence the time has come, to think of using alternate non conventional sources of energy in the household sector to solve the fuel problem.

In this regard the late Prime Minister, Indira Gandhi made an impassioned plea for the development of indigenous technology in preference to imported technology in the rural areas to reduce the drudgery of the rural women. The Department of Science and Technology, Government of India (1982) has identified some improved cooking stoves, biogas plants and solar devices, as measures to alleviate the drudgery facing Indian women and reduce the demand on fuel wood.

One of the important steps which could be taken towards prevention of continuous deforestation, depletion of forest resources, loss of human energy and time spent in cutting and carrying wood over long distances, is the introduction of efficient and energy conserving cooking appliances.

The traditional wood stove has remained the same for hundreds of years and is a highly inefficient making available less than six per cent of the energy released by the fuel (Gupta, 1982). An improvement in the efficiency of these Chulahs can reduce half the nation's consumption of 130 million tonnes of firewood every year. In this context, the use of smokeless chulah will not only make the women folk healthier but also increase their life span. (Grover, 1982). By introducing smokeless ovens, women will be freed from smoky kitchens where they spend more than 70 per cent of their time and suffer from the hazards of smoke on their eyes, lungs and skins.

Besides improving the cook stoves, there is need to find out appropriate alternative energy sources for cooking (Sharma, 1984). Biogas plant, which appears to give an ideal source of fuel and a valuable manure as efficient slurry is a boon for India which has a high cattle population and agrarian economy (Kalia, 1981; and Rao, 1984). As Parmora (1983) has computed, about 303 million MWh of energy as biogas and 368 million tonnes of manure per year can be produced through biogas plants from the available cattle dung alone.

Realising the urgency and need for conservation of energy, a National Biogas Development Project was launched in the sixth plan. In the current 20 Point Programme, emphasis has been placed on the need for developing biogas and other alternative energy sources (Ministry of Information and Broadcasting, Government of India, 1984).

Shah and George (1982) view that usable, renewable energy sources should have ample thermodynamic and economic availability, ecological safety, inoffensiveness and freedom from hazards. They should depend upon known technology which can be developed within the constraints of resources and man power. Among the alternate sources that man is trying to tap such as solar energy, wind power energy, geothermal energy and tidal power, solar energy appears to be an appropriate option, since the other sources involve high technological development.

Solar energy is the most promising means from the point of view of availability, cleanliness and ecology (Gupta, 1974; Culham, 1975; and Pichai, 1984). Gnanarathinam (1982) puts forth that solar energy is our largest and ultimate non fossil, non nuclear energy source. Devadas (1980) has pointed out that solar energy offers a practical solution for the household energy problem which is clouding the prospects of mankind.

In India, abundant sunshine is available for atleast eight months during the year. The average intensity of solar energy in India is 600 cals/sq.cm/day (Anand, 1983; and Vijayaraghavan, 1984). According to Patel (1977), the geographical location of the country at 7 to 37^{o} North Latitude has a large potential for solar energy utilisation. India gets 3000 hours of sunshine a year and has advantage to tap this source of energy to meet the energy requirements of the rural parts, where there is practically no electricity (Rao, 1980; and Pichai, 1984).

Cooking makes one of the primary demands of energy in all societies. Solar energy can be used for cooking and save energy. Solar cookers and ovens have been developed for cooking all types of food within 40 to 60 minutes on a sunny day. These cookers can be fabricated with locally available materials and can become effective device for the housewife on all sunny days, that is about 240 to 300 days in a year. Solar cooker saves the time spent in collecting fuel. It provides safe, uniform heating and hygienic cooking with no hazards of smoke and fire. The applications of this energy source will open the flood gates of a new economic activity throughout the country (Tarcici, 1974; Tuve, 1976; Rao, 1980; Ravindra, 1981; and Vaithilingam, 1984).

Several researches have been undertaken to develop smokeless chulah, solar cookers and biogas designs, since they are the most appropriate devices needed in the Indian households. However, transfer of these technologies to the Indian villages poses a major challenge. If done efficiently it will solve the problems of the energy crisis to a great extent. Unfortunately most of the researches do not go out of the laboratory and never reach the people for whom they were carried out. Pant (1983) points out that even though our scientists and technologists have evolved over the years a variety of designs of improved chulahs, the problem is to find ways and means of extending the designs for acceptance by the village households. Proper training, extension and demonstration programmes together with continuous research and follow up work will benefit the rural communities by reducing their energy needs and also help to solve the national energy crisis (Gupta, 1982).

Keeping in view the need to extend the smokeless chulah and other devices to help homemakers in the rural households, conserve the energy expenditure in cooking, the present study was undertaken to motivate selected rural homemakers to adopt better fuel management practices, with the following objectives:

1. Understanding the fuel management practices adopted by the rural households,
2. Selecting the appropriate and efficient design in smokeless chulah, biogas plant solar cooker by conducting experiments,
3. Motivating the rural families to adopt these improved fuel management practices and
4. Studying the impact of introducing these technologies in terms of fuel consumption, time expenditure and benefits and constraints faced by the homemakers in adopting the improved fuel management practices.

The investigator hopes earnestly that the findings of this study would give an insight into the possibilities of utilising the available resources, to foster better fuel management practices in the rural communities and also offer suitable guidelines for future research, policy decisions and actions in the field of 'energy management'.

II. REVIEW OF LITERATURE

The literature pertaining to this study has been reviewed under the following broad headings:

A. Energy Scene in India,

B. Improved Cook Stove - Smokeless Chulahs,

C. Biogas Technology

and D. Solar Energy for Household Purposes.

A. Energy Scene in India

This aspect of the study is dealt with under the following sub headings:

1. Importance of Energy in National Life,
2. Sources of energy and extent of its availability

and 3. Need for Renewable sources of energy.

1. Importance of Energy in National Life

Modern civilization depends on the availability and level of consumption of energy. Human life is dependent on the constant expenditure and conservation of energy. Exploitation and manipulation of energy are essential for man's survival (Simon, 1975; and Ghosh, 1979). The magnitude, type and nature of use of energy throughout the ages have determined life styles, economic prosperity, military power and the social mover of various countries at different parts of time (Sethna, 1977). Energy controls our lives, our economy, our international relationships, our standard of living and our culture (Odum and Odum, 1971; Devadas, 1980;and Raghuraman, 1983). Brink worth (1972) and Bhaduria (1980) are also of the view that one of the primary needs for national development is power. Power is needed to produce things and process them at rates far beyond the capacity of manual labour. Energy is considered as the one of the main inputs for rural development (Arokiaswamy, 1978; Bhaduria, 1980; and Iyer, 1985). An energy deficient society is weak and incapable of adapting to fast changing environmental conditions, in comparison to an energy high society.

Energy has many dimensions. To the consumer it is commodity he buys as gasoline, natural gas and electricity; to engineers it is the heat for industrial furnaces or the motive force that powers machinery; to the economist, it is a key ingredient in national prosperity (Hammond et. al., 1975).

Energy is present in various forms namely heat and light radiated by the sun, in the carbohydrates in wood and plants, in coal, oil, and natural gas, and oil state and tar sands, geothermal wells, in the wind that sweeps over the land and sea, the water coursing to the oceans, and in the atomic nucleus (Culham, 1975; and Encyclopaedia of Energy, 1976).

Energy is used practically in every sphere of human activity and the process of economic development calls for increasing use of energy. Devadas et. al. (1983) stress that energy which is a crucial factor in technological development has always been the key to man's greatest goals and to his dreams of a better world. Since energy being a vital requirement for economic development, it is needed in increasing amounts to improve agriculture and industrial production and thereby provide better quality of life (Kaskari, 1975; Rao, 1983; and Iyer, 1985). Energy in diverse form is needed for accelerating economic growth and to provide a good standard of living for the people. The four energy consuming sectors are industrial, agriculture, transport and domestic (Parikh, 1976; and Kapur, 1979).

2. Sources of Energy and extent of its availability

Energy sources are classified as primary, secondary and non commercial. Primary sources include coal, lignite, natural gas and oil in addition to nuclear and geothermal energy. Secondary source comprises coke, gasoline, kerosene, fuel oil and thermal electricity. Non commercial sources are bagasse, firewood, charcoal, animal dung, paddy husk and vegetable and food wastes.

According to Ramachandran (1980), Malhotra (1983), Kanawade and Ingle (1984) and Ahsan (1985), energy sources have been divided into two categories - commercial and non commercial. Coal, oil, hydro, nuclear and electricity are called commercial energy resources. Firewood, crop waste and animal waste are classified as non commercial.

a. Commercial sources of Energy

Coal is the most abundant resource of commercial energy in India today. The present production of coal and lignite in India is of the order of about 114 million tonnes and 5 million tonnes respectively. But it should be noted that the share of India's coal reserve is only about 1.5 per cent of the world's coal reserve (Das, 1983). The coal which is abundantly available at present will also be exhausted if it is exploited without any restraint (Sivanandam, 1974; and Rao, 1980).

Oil is a versatile fuel used for a variety of purposes in all the sectors of economy. The production target of domestic oil, both on land and off shore for 1984-85 was 21.6 million tonnes, while the demand may reach a level of 45.5 million tonnes.

The total installed power generating capacity in India which was only 2300 MW in 1950, increased to about 32410 MW by 1981-82. During this period the per capita annual consumption of electricity also increased steeply from 18 kWh to 130 kWh (Ahsan, 1985).

Ahmed (1978) points out that during the last 25 years India has been burning larger amounts of energy than what she has been consuming earlier. The consumption of coal increased from 28 million tonnes to more than 78 million tonnes, of oil from three million tonnes to more than 20 million tonnes, and electricity from 6500 million kWh to more than 65000 million kWh.

From these trends it has been estimated that in 2000 AD the nation shall require four times the present availability of coal, twice the present quantity of oil and about four times the present installed capacity of electricity (Talwar, 1979).

The Tata Energy Research Institute (1982) indicates that the demand of total energy during the period 2000-2001, is expected to be more than two times the expected demand in 1982-83. The share of commercial sector is 65.32 per cent in 1985-86 and it will rise to 71.30 per cent in 2000-2001. This leads to the conclusion that, the demand will depend more and more on the non renewable sources which will be depleted soon.

b. Non Commercial Sources of Energy

The most striking feature of India's energy scene is the importance still played by non commercial forms of energy (Rao and Vaidyeswaran, 1981; Das, 1983; and Lavasa, 1985).

Sathe (1982) gives the energy consumption in Rural India as described in Table I.

TABLE I

ENERGY CONSUMPTION IN RURAL INDIA

Sl. No.	Energy source	Annual amount trillion kilo calories	Percentage share
I.	NON COMMERCIAL		
	Firewood and charcoal	460	52.7
	Dried dung	186	21.3
	Crop residues	107	12.3
		753	86.3
II.	COMMERCIAL		
	Oil and natural gas	85	9.7
	Coal and soft coke	14	1.6
	Electricity	21	2.4
		120	13.7
	Total I and II	873	100

The bulk of the energy needs of the kitchens in rural India is met from non commercial sources like firewood, agricultural waste and cowdung. Together they provide 86 per cent of the cooking energy requirements, while coal, kerosene and electricity provide only 14 per cent of the energy requirements for cooking, as described in Table I.

Firewood is the most important non commercial fuel in India (Kamat, 1982; Desai, 1983; Hoda, 1983; and Kodli, 1985). It is obtained from forests, privately owned plantations, wood lots, trees from the road sides and on the banks of rivers and canals. Firewood accounts for about two thirds of the total energy contribution from non commercial sources in rural households and about 40 per cent in urban households. Studies on domestic energy consumption pattern in India have shown that 90 per cent of the households in rural areas, 75 per cent in the semi urban areas 25 per cent in the urban areas use firewood for cooking. (Prasad, 1984). Out of the 685 million people in the country 600 millions use wood for fuel because of its cheap and easy availability (Relwani, 1984).

India's current consumption of firewood per year is estimated at 133 million tonnes (Jena, 1981; and

Sharma, 1984). India's forest and non forest lands are at best supplying 103 million tonnes of fuel wood, with a deficit of about 30 million tonnes (Relwani, 1984).

The crisis will become even more acute with the depletion of forests which today meet the most basic need, that is fuel for cooking. In India 68.5 per cent energy is used in the form of firewood in household sector and 64.2 per cent of it is collected from natural sources (Khoskhod, 1983). This heavy demand on firewood results in depletion of forests which in turn has proved to be ecologically, disastrous as it leads to floods, soil erosion and ultimately shortage of water.

The Fuel Policy Committee's estimation of non commercial fuel is as shown in Table II.

TABLE II

ESTIMATED NON COMMERCIAL FUEL SOURCES UPTO 1991

Sl. No.	Fuel	Million tonnes		
		1978-79	1983-84	1990-91
1	Firewood and charcoal	132	131	122
2	Cowdung cake	65	65	53
3	Vegetable Wastes	46	46	46

The non commercial fuel resources are dwindling fast. Agricultural wastes are excess of agricultural production that have not been effectively utilised. Patel and Pandya (1979) remark that the agricultural wastes are utilised in three-ways-fertiliser, fuel and food to the animals. Agricultural wastes such as rice bran, rice husk, hay from paddy, cholam stalk sugarcane bagasse, dried chillies plants, bringal plants, cotton stalks are used by the families as fuel. The amount of agricultural wastes available as a source of energy depends on the extent of agricultural production and varies with different crops.

India with its large population of cattle, can have no difficulty in obtaining adequate supplies of cattle dung (Pandey, 1982). But unfortunately the animal dung is used in the form of cakes in the rural areas. (Srinivasan, 1980; Sivanappan and Subramaniam, 1981). Gautam (1974) points out that the efficiency of cowdung cake is only 11 per cent whereas that of the gas from fermented cowdung is 60 per cent.

3. Need for Renewable Sources of Energy

Renewable sources of energy are those sources which nature continuously renews on its own. They include direct energy from the sun (solar energy), wind energy, biomass energy (including fuel wood and charcoal) hydropower, ocean energy and animal waste. Mankind has used these sources from ancient times for his various needs such as drying. cooking, heating, lighting, mechanical power and transportation. Of the renewable sources of energy, only hydro energy and geothermal energy are being used for electric power generation in a substantial way. The other renewable sources continue to be used wherever they are used, largely in traditional ways.

Several scientists have highlighted the relevance of alternate renewable sources of fuel for a developing country. The sharp increases in oil prices, uncertainties in supplies, difficulties in producing and transporting increasing amounts of fossil fuels, environmental degradation caused by conventional fuels are among the factors which have led India to focus attention on renewable energy sources. (Ratnam, 1974; Bhattacharya, 1983; Sukhatme, 1984; Ahsan, 1985; and Dayal, 1985).

The increase in the price of petroleum crudeoil by the OPEC (Oil Producing and Exporting Countries) in 1973 by 300 per cent, made all sectors of population from the politicians and policy makers to the common man, realise the urgency of developing alternate sources of energy. The energy crisis due to the increase in per capita consumption of the population and decrease in fuel supply, demands that the nation looks for alternate energy sources (Wilson, 1977).

Babu (1983) opines that frequent failures of monsoons and non availability of fossil fuel have resulted in inadequate power supply to the agricultural sector and calls for a search for newer sources of energy that will be cheap and uninterrupted by nature. Bachkheti (1982), Avinashilingam (1984) and Patel and Dhongade (1984) view that the problem of non availability and the high cost of fuel will be grave in the near future, in view of the expanding industries, increasing population and continuous depletion of forest resources. Furthermore, scarcity of electricity, non availability of coal and firewood and the exhorbitant price of kerosene, call attention to search for an alternate source of energy (Devadas et. al., 1983).

Shah (1974) points out that demand for fuel wood has been rising commensurate with the increase in population. This demand which leads to an ever faster removal of trees from the country sides. Thus a dangerous situation in which the demand for fuel wood is rising progressively, while the fuel wood producing resources have almost dried up. Trees cannot be grown overnight and would take a minimum of 15 to 20 years before a tree can be felled even for firewood.

Pal and Kalra (1981) mention that wood is very rarely available in the nearby forests because of the rural development efforts in the form of roads, buildings and other amenities for the rural people. Jungles have also become scarce in the nearby areas because of collecting wood since time immemorial. Danam (1981) mentions that forests meet the major demand of firewood in the country side as well as in the urban areas as other cooking medium like LPG are not within the reach of common man. RERIC (1983) reports that the dwindling supplies of fuel wood is not a question of energy for development but rather of energy for survival.

Mayur (1980) warns that if the loss of the forests (at the rate of 30 million hectares a year), the soil erosion, environmental degradation and general conditions of poverty, continue at the present rate, the results will be catastrophic by the end of the century. In this context as a protective measure, the Chipko Movement was born in 1973 in the remote hill town of Gopeshwar in Chamoli District focussing the attention on the mismanagement of forest resources. The message of this Chipko Movement was spread to the neighbouring areas by a journalist, Bahuguna, by conducting a campaign against deforestation (Bahuguna, 1972; and Agarwal, 1983). Apart from these measures special guard-squads and mobile courts have also been set up to combat 'tree-poaching' in legally protected areas (Eckholm, 1976).

In order to alleviate this problem, along with the forest replanting schemes, alternative fuels are also urgently needed to take the pressure off poor people who are struggling to find firewood and also take the strain off the forests (Shanmugam et. al., 1984). At this juncture, there are certain energy sources hitherto unexploited, and appropriate for our rural conditions namely 1. Energy from waste materials, 2. Energy from wind and 3. Solar energy (Behari, 1974; Lakshmanan and Nallathambi, 1980; Ng and Loung, 1982; and Subramanyan, 1986).

As Anand (1983) states that India may be poor in fossil fuel resources but she is doubly blessed with sunlight, water, good soil, manpower and an enduring agrarian economy. The main opportunities lie in the efficient harnessing and conservation of renewable bio-energy systems sustained by solar energy. Rural India needs continuous and cheaper sources of energy for development through non-conventional energy sources, such as biogas, solar and wind.

The National Seminar on Energy for Rural Development (1983) indicates the energy needs in villages as follows:

1. Cooking energy demand = 31.59×10^3 kcals/day/family
2. Energy for cattle feed preparation = 8.91×10^3 kcals/day/family

3. Energy for washing cleaning etc. = 1.79×10^3 kcals/day/family
4. Energy spent on festivals = 126.4×10^3 kcals/year/family
5. Energy required per farm = 447.2×10^3 kcals/year/farm
6. Energy required for farm produce transportation = 9.3×10^3 kcals/year/farm

The substitution of fuel energy required for these sectors can be through demonstration of alternative energy sources (Altekar and Sampath, 1977).

The contribution of renewable energies depends on a variety of factors. Any policy for renewable energy development will face several constraints which arise in the context of utilising them on a large scale.

One of the most important constraints in the wider utilisation of renewable energy systems is the high initial (capital) costs. The cost of a solar or wind device today is considerably higher than that of the product based on conventional fuels. In a country like India, where capital is relatively scarce and where individual earnings are not high, this is a deterrent to most potential users of renewable energy system. For example, the relatively simpler units of biogas plants are also beyond the reach of a large percentage of farmers (Kodli, 1985). The problem of high cost of renewable energy systems can only be overcome through technology improvement, material and manufacturing development, and a package of fiscal and other promotional measures.

Widespread utilisation of renewable energies will require a suitable infrastructure for the manufacture, installation and servicing of renewable energy systems. The problem of infrastructure development is related to economic considerations, socio-cultural parameters and general awareness. Special efforts will therefore be needed for the development of infrastructure, manufacture, installation and maintenance of the new systems.

An awareness has to be promoted regarding the newer techniques which offer more efficient ways of utilising the renewable sources. A code of solar ethics has to be cultivated wherever there is potential for the utilisation of solar energy. Certain habits and cultural practices may have to be changed if renewable energy devices are to be used on a wide scale. A few such changes are:

a. Solar cookers require certain cooking schedules and methodology which are different from existing practices,
b. The sharing of inputs for and outputs from community installations (such as biogas plants) requires a certain type of organisation of social structure and

c. The wind patterns in many areas are such as to require changes in the agricultural cropping patterns and schedules if the wind energy is to be used to provide water for irrigation.

The spread of modern renewable energy systems is limited because a large percentage of population is illiterate and the people themselves divided into a large number of languages, affecting the communication process which is essential for any awareness programme.

The technological constraints limiting the development and utilisation of renewable energies include suitable materials of renewable energy systems. Out of the renewable sources of energy such as solar energy, geothermal energy and tidal power are not yet untapped largely in India because of limitations in existing knowledge and techniques (Bose, 1981; and Kandpal and Mathur, 1982).

However, the planners and policy makers today are seriously concerned with the problem of energy crisis and fuel wood shortage. The nation is making concerted efforts to find alternate, renewable sources of energy to combat the problem of shortage of conventional and non renewable sources (Ganger and Balasubramanya, 1983). Tyagi (1984) and Kodli (1985) rightly suggest that creation of energy forest for each village seems to be the only alternative for the rural energy problem.

Schemes such as 'Social Forestry' including 'Rural Fuel Wood Plantation' were undertaken in 100 districts in the Sixth Five Year Plan (1980-85) at a total cost of Rs.100 crores. The scheme envisaged raising fuel wood plantations near the villages on waste lands, village common lands and along the sides of the road, canals and railways. For this purpose free supply of seedlings to farmers for planting in and around their farms and supply of seedlings to children to grow fruit trees were made under the 'A tree for Every Child Programme'.

It is laudable, that at this juncture, India's Prime Minister, Honourable Sri Rajiv Gandhi, has proposed to set up immediately a National Waste Lands Development Board, with the object of bringing five million hectares of land every year under fuel wood and fodder plantations and to develop a people's movement for afforestation (Rajiv Gandhi, 1985).

The Sixth Five Year Plan recognised the importance of energy conservation and the need to develop new and renewable sources of energy. The broad approach encompassed the following objectives:

a. To implement on a large scale, programmes such as those of energy forestry and biogas where technology development has already reached a stage which permits field application,

b. To carry out field testing and demonstration on a country-wide basis of technologies which have the potential to become commercially viable in the succeeding five to seven years and

c. To intensify research and development of other technologies where the potential is likely to be available over a longer time.

The programme covered all important new and renewable sources of energy such as solar, wind, biomass chemical and geothermal energy and their applications in various sectors.

The government also proposed to promote the wider utilisation of renewable energy system through various incentives, subsidies etc. The plan provide Rs:500 million to be spent on subsidies and supporting facilities for the establishment of family biogas plants. Government had also announced exemption of solar, biomass and wind energy devices from excise duty. Integrated rural energy systems were proposed by the Government especially for meeting the needs of the rural population by taking into account all available energy resources in an area with particular emphasis on new and renewable energy technologies (Sapru, 1983).

The Department of Science and Technology is funding R and D programmes which are being executed by over 40 national laboratories, public sector undertakings, Indian Institute of

Technology, Universities and other bodies. The main objective of the R and D programme would be to overcome technological and material constraints that are currently impeding the wider utilisation of renewable energy sources, to explore newer areas where renewable energy sources can make a significant contribution to national development, to bring down the initial costs of renewable energy devices, and to develop reliable devices and plants. In addition to these, government has recently established a Commission for Additional Sources of Energy (CASE). The Commission will be,

a. Formulating policies and programmes for development of new and renewable sources of energy,

b. Co-ordinating and intensifying research and development activities in new and renewable sources of energy and

c. Ensuring implementation of Government's policies in regard to all matters concerning new and renewable sources of energy.

The Government has set up specialised centres in various parts of the country to assist the Commission for additional sources of energy, in maintaining and updating the data bank on renewable energy sources, disseminating technical information, providing technical guidance to potential users of renewable energy systems and undertaking projects in the field.

B. Improved Cook Stove - Smokeless Chulahs.

This aspect of the study is discussed under the following headings:

1. Need for smokeless chulah in the rural areas.
2. Salient features of Smokeless chulah.
3. Types of smokeless chulahs.

1. Need for smokeless chulah in the rural areas

A majority of the world's population living in backward areas use cooking devices which are smoky, primitive, unhygienic and wasteful. They constitute a world problem affecting simultaneously, housing, fuel economy, health-physical and mental and forest economy (Perumal, 1983).

The ordinary 5000 years old household open chulah, has an extremely low thermal efficiency, when food is cooked. The amount of heat actually absorbed by the substances cooked is extremely low, compared to the heat given out by the wood consumed during the process. The losses are due to the unscientific method of burning wood, inefficient design of the cooking device and uneconomical cooking methods employed by the housewives (Batliwala, 1983). The improved cook stoves having a combustion efficiency of more than 15 per cent have drastically cut down consumption of firewood (Hindu, 1985).

It is estimated that in the open fire cooking on a traditional chulah, only 5-10 per cent of the potential energy in the wood fuel is utilised, and the smoke emitted in the open fire cooking is a serious health hazard particularly for the housewives and children who are exposed to the smoke most of the time (Grover and Sharma, 1981; Prasad and Mandal, 1983; and Salariya and Jindal, 1983). According to the studies at the East-West Centre in Hawaii, U.S.A., the amount of carcinogenic particles emitted by smoke fire in enclosed kitchens, can be equal to smoking 20 packets of cigarettes. Smoke from wood burning stoves and fire places contain 17 major pollutants, 14 known cancer causing substances and toxic agents (Kokry and Muglani, 1980). The misery of cooking on open smoky chulahs has become a part and parcel of the daily routine of Indian families.

The kitchen has a definite contribution to make towards the health and comfort and therefore the happiness of the family. Often the Indian kitchens are suffocating chambers of pungent smoke violently irritating the eyes, nose and lungs, and also the temper of the housewife. Open, smoky chulahs needing frequent blowing of fire, and backwalls dirty with soot, creates an environment, which is unhygienic, inaesthetic and depressing. About 100 million women of India spend a quarter of their lives in a gloomy kitchen with thick layers of smoke, due to burning cowdung cake and firewood. Smoke nuisance is a public health problem and serious health hazard. 'The kitchen kills more than a sword', is an old German saying. Smoky kitchen is messy, unsanitary and requires ceaseless attention. For judging the health and living standards of people, there is hardly a better index than the standard of their kitchens.

The system of cooking meals two or three times a day is a common feature in India. Smoke blackens the utensils beyond cleaning. Much time and efforts are wasted in cleaning the utensils (Salariya and Jindal, 1983).

Therefore, improved, well designed, fuel efficient, low cost and appropriate smokeless chulahs should be made available to the poor families. By doing so, an effective solution to the problem of fuel wood crisis, deforestation process and soil erosion will be found (Indira Gandhi, 1981). Considering all these facts the improved thermal efficient smokeless chulahs are the best and cheapest measure to mitigate the health hazards and the drudgery of rural women and the most effective fuel wood conservation method (Pandit, 1983; Devadas, 1985; and Vedant, 1985).

The advantages of smokeless chulahs, have been enumerated by several authors.

Smokeless chulah ensures a clean and safe cooking process. Due to elimination of smoke and soot, the kitchen will be clean and made a cheerful place for the family to gather in. The other adjoining living apartments will also be free from irritating smoke and blackened walls. (Phadnis, 1983; and Srivastava, 1984)

While based on scientific principles, the smokeless chulah is simple in design, construction and use. It can be adopted for the needs of the families of different sizes and income groups, hostels, schools and restaurants. Smokeless chulah is readily adaptable for burning a wide range of locally available fuels.

Because the time spent in cooking and the drudgery involved are reduced by using smokeless chulahs, women find more leisure to be spent on useful income generating activities. Further-more the construction and sale of smokeless chulah promotes job opportunities for rural artisans.

The study conducted by Social Work and Research Centre (SWRC), Jagjitpur (1983) shows the following benefits:

1. Reduction in fuel consumption; effective removal of smoke from the kitchen with its concomittant impact on the discomfort and irritation caused to the eyes as well as reduced time spent on washing blackned kitchen walls.

2. Household goods remain clean.
3. Time is saved in cooking and cleaning of utensils.
4. Removal of ash is minimised.
5. Time spent in fuel wood collection is saved.

Devadas <u>et.al</u>. (1983), Phadnis (1983) and Srivastava (1984) narrate the following benefits:

1. Kitchen is smoke free,
2. The draft helps in starting and maintaining bright fire,
3. Heat from fuel is more fully utilised the saving of fuel is about 25 per cent if used properly,
4. The person cooking is freed from getting scarched by radiated heat,
5. Designed to use wood fuel completely,
6. Heat could be controlled,
7. Makes cooking a cheerful occupation as there is no smoke or heat reaction and
8. Small chips of dried fuel help to start the fire easily.

The wide spread adoption of improved cook stove designs may be an important strategy to help in improving the environment by control of fire intensity and smokeless operation (Sodha and Prasad, 1981).

The use of smokeless chulahs should be popularised all over the world specially in villages where the majority of population lives. The use of smokeless chulah will not only make the women folk healthier but will also increase their life span (Salariya and Jindal, 1980; and Pant 1983).

2. Salient features of smokeless chulah

Smokeless chulah incorporates the following cardinal principles:

a. A closed hearth where the combustion of wood takes place. This protects the loss of heat through wind, draught etc.

b. A multiholed design that makes it possible to prepare two or three items, simultaneously although only one hole will feed the fuel.

c. A chimney to provide the draught necessary for bringing in air for accelerating the combustion process and also for removing smoke pollution (Paul, 1983).

The main parts of the 'smokeless chulah' are a closed hearth, flue and a chimney. The Hearth is the area to hold the burning end of the wood and the embers giving the flame enough room to grow and is also called the fire place. The flue is the passage providing the heat between the pot seats. It must be designed to concentrate the flames and the fumes at the pot seats before they are carried out of the stove.

When the flames pass through the pot seats, most of the heat is absorbed by the vessels on them. As the gas is heated it will rise and as a result of an upward flow, provided by the low pressure area created within the chimney, it causes the gas to move continuously upward and this flow is known as draft (Sharma, 1983). Against a satisfactory draft smoke cannot retreat and it is necessary that no leakage of smoke is allowed between the pot and the hearth (Joslin and Taylor, 1963).

The chimney is the chief feature of smokeless chulah to direct smoke out of the kitchen. The hot smoke has a tendency to rise towards a smoke outlet. But when the heat in it is slowly absorbed, by the atmosphere, it ceases to rise up. When it is left absolutely devoid of heat, it becomes denser than air and being reluctant to rise up, it whirls round and round with the breeze and spreads all over the place. Hence it is essential to keep the smoke free from outside cold air, until it reaches the top of the chimney and mingles with the breeze. For efficient functioning, the chimney should be erected one foot above the roof (Patel, 1983).

The features of smokeless chulah mentioned by Raju, as early as in 1957 are given below:

1. The chulah should have a simple design with a minimum of two pot seats.
2. It must be smokeless at the time of cooking.
3. The construction of such an arrangement should be simple for general adoption in every home.
4. The materials required for its construction should be locally available.
5. It should be capable of being worked with different types of fuel like crop stalk, firewood, cowdung cake etc.
6. There should be provision for cooking on two pot seats simultaneously.
7. The cleaning of the chulah and removal of ash from its inner portions must not create any difficulty.

3. Types of Smokeless chulah

Efforts have been made all over the country to design various models of smokeless chulah.

a. Two-pot chulahs

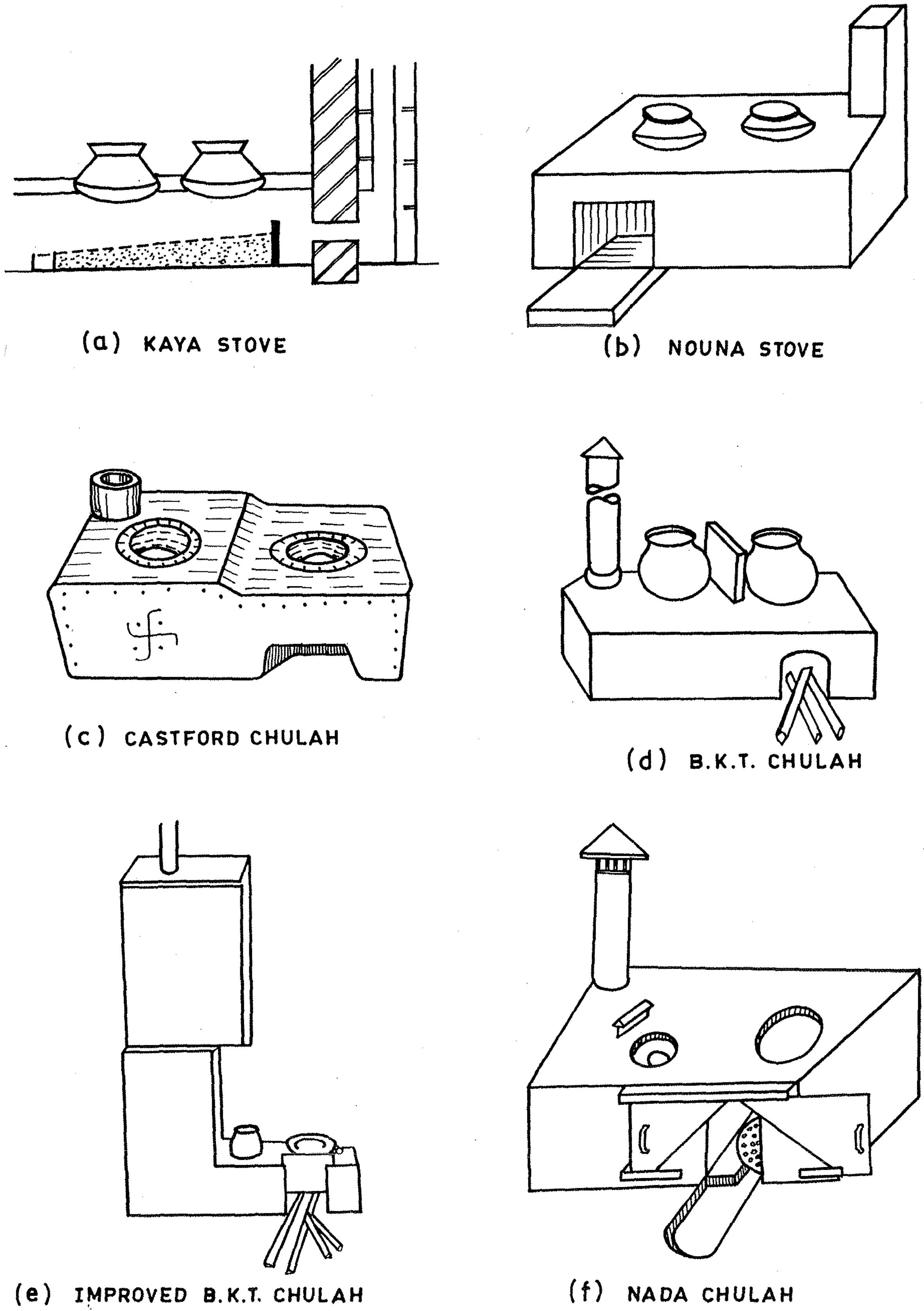
A chulah in which cooking operation can be carried out in two pots simultaneously is called a 'Two-pot chulah'. Some models which have been propagated are described below:

i. Kaya Stove: This stove is used in Kaya and is made of concrete sand, a hoop of mild steel rod and angle iron. It has two pot seats, one behind the other. The pots are sunk below the stove top for better heat utilisation. A chimney made of prefabricated block is used for the removal of smoke (Gern, 1980) (Figure 1a).

ii. Nouna Stove: This stove is made from bricks, mortar and mild steel rod. The chimney used is made of fire bricks and mortar. It has two pot holes, 8 cm. apart. A baffle is provided under the second pot hole (Figure 1b).

iii. CASTFORD Chulah: CASTFORD, Pune has designed an improved chulah. It has two seats, one directly above the fire-box. It has a chimney to make the kitchen smokeless. It is designed to burn fuel wood and animal dung cakes. It is portable and made from locally available materials (Figure 1c).

iv. Bakshi-Ka-Talab Chulah: The BKT chulah consists of two pot seats and a feeding mouth. The flue is the passage connecting the two pot seats. The chimney is made of galvanised iron and the chimney base is curved sloping towards the fuel feeding mouth. The cowl is placed on the top to protect the chimney. Dampers are provided between the first and second pot seat to act as a control for transfer of heat between them and to avoid free escape of smoke.



TWO POT CHULAH

FIGURE 1

The second perforated damper is placed between the second pot seat and chimney base to retain hot gases for longer time in flue. The baffle wall is erected at the second pot seat so that the flames would strike the pot and the smoke would find its way to the chimney (Figure 1d).

v. Improved Chulah of BKT Type: Research studies have been conducted, at Sri Avinashilingam Home Science College, Coimbatore in the early years' indicated among the three types of chulahs, namely 'Raju Chulah', 'Samadhan Chulah' and 'BKT Chulah', the BKT type was proved to be the best resulting of maximum saving of time and minimum fuel consumption.

The BKT chulah has been studied further and certain modification were effected. The improved chulah consists of two pot seats. A two level first pot seat was specially constructed for baking chappathi; and the second pot seat had the same diameter as for the first pot seat. Ash outlet opening was made in the side wall, near the grate, to make removal of ash convenient and to aid in ventilation. A square metal sheet was used to close the fuel feeding mouth which could be adjusted to the desired height, to regulate the supply of air and then the speed of combustion as required. Grate was fixed 4 cm. above the base to keep the wood in an inclined position to supply air from below.

Dampers were avoided to minimise the required accessories of chulah to avoid complication in construction. Provision for hot water simultaneously during cooking was the very special feature of this chulah. A container was fixed 23 cm. above the surface of the chulah around the chimney, so that convection currents passing through the chimney would be used to heat water (Devadas et. al., 1983) (Figure 1e).

vi. Nada Chulah: This chulah developed by Sharin (1982) is smokeless and consumes less firewood. It contains 2 to 3 pots made of mud and bricks (Figure 1f).

b. Three pot chulah

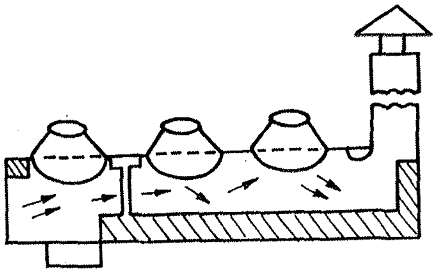
A three pot chulah consists of three pot seats. One pot seat is generally on the fire box and the other two are located on the passage of the flue gases, that is in between the first pot seat and the chimney.

i. Magan Chulah: This appliance was developed by the All India Village Industries Association at Maganwadi, Wardha in Mahatma Gandhi's time. The Magan chulah named after Magan lal Bagri who developed the chulah. This three pot chulah is made from clay mixed with horse dung/straw/ cowdung, metal grate, metal ringe, a clay pipe for chimney, collar and cowl. The pot seats are in a triangular configuration and one of these is above the fire box. A damper is provided for controlling combustion and is located between the first and second pot seats. Risers are provided in the flue passage to direct flue gases towards pots. The provision of grate and chimney in this design leads to better combustion of fuel and also makes the chulah smokeless (Figure 2a).

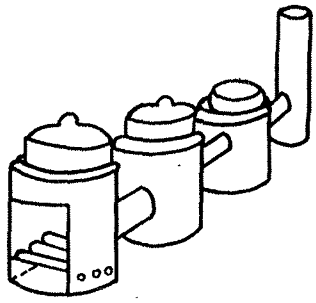
ii. Portable Magan Chulah: The portable Magan chulah consists of ovens that serve as pot seats and a chimney base and round flues connecting the ovens (Figure 2b).

iii. Dhauladhar Chulah: Dhauladhar chulah has been designed by the Indo German teams of scientists at Palampur. It is a three pot chulah with a chimney. The fire is burnt under the front pot, which gets direct heat. The other two pot seats are heated with flue gases, which get out of the kitchen through the chimney at the back. Two dampers have been provided to control the draft of air. The first damper, made in two halves, is fitted at the face of the fire place and the second damper is fitted at the base of the chimney. These dampers and the chimney are made from thin mild steel sheet while the rest of the chulah is made of bricks and clay (Salariya, 1983) (Figure 2c).

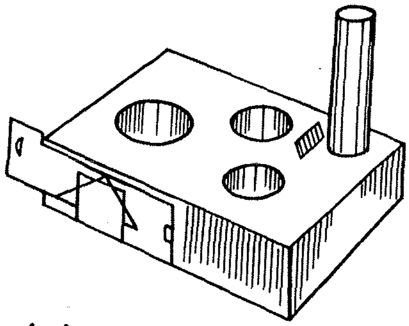
iv. HERL Chulah: HERL Chulah was developed at Hydrabad Engineering Research Laboratories. This was also known as 'Raju Chulah' in the earlier years, named after the Director of the



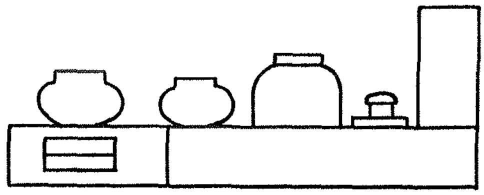
(a) MAGAN CHULAH



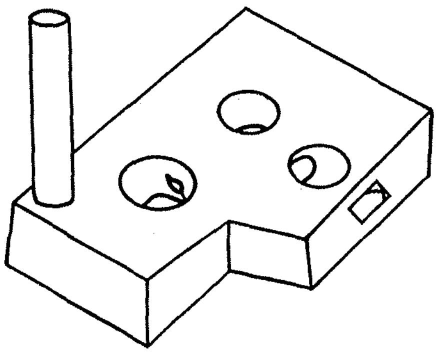
(b) PORTABLE MAGAN CHULAH



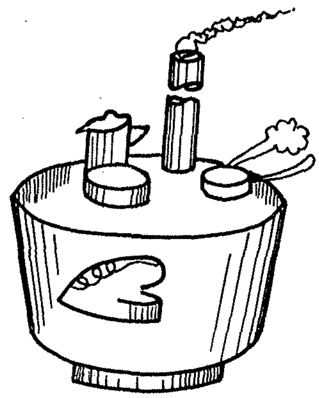
(c) DHAULADHAR CHULAH



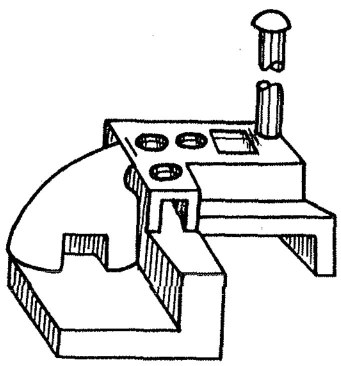
(d) HERL CHULAH



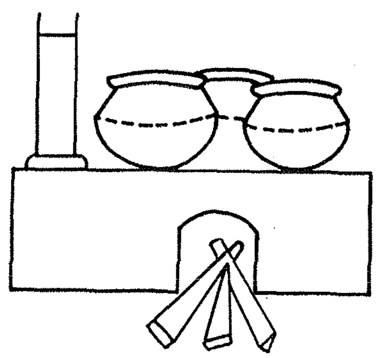
(e) JANAGADH CHULAH



(f) LORENA STOVE



(g) SMOKELESS STOVE GHANA



(h) SAMADHAN CHULAH

THREE POT CHULAH

FIGURE 2

Institute. It was designed as a simple structure built up of only mud or brick and mud plastered with fire earth. It consisted of an 'L' shaped duct with one, two or three holes for cooking pots and an opening for the fire wood. At the end of the duct was an arrangement for a big pot of water where the hot gas before going out would be further utilised thus providing an automatic supply of hot water for the family. Provision of chimney renders it smokeless. An adjustable damper between hot water pot and the chimney is used for regulating the draft (Figure 2d).

v. <u>South Division Janagadh Chulah</u>: This chulah resembles HERL chulah except for anti clock wise flue gas flow, chimney has been provided for exhaust gases but there is no damper for control of combustion. (Ahuja and Gupta, 1968). This chulah design has been further improved by National Building Organisation in collaboration with Planning Research and Action Institute, Lucknow, and the improved designs has two pot holes in L shape, a chimney and a damper for draft control (Figure 2e).

vi. <u>Lorena Stove</u>: This stove was developed by the Appropriate Technology project of volunteers in Asia in 1976. It is made from clay, soil, sand, brick, adobe and scrap sheet metal. This stove has three to five pot holes. One directly over the firebox and others heated by flue gases. Provision for two dampers has been made in this stove, one for connecting the mouth of the fire box and first pot hole, and the second between last pot hole and the chimney. The risers provided at the bottom of pot holes force the hot flue gases towards the pots (Figure 2f).

vii. Smokeless Ghana Stove: The Ghana stove is used mostly by the people of Ghana. Clay, laterite, sheet metal, bamboo, reinforcing rods, and scrap tin are used as raw materials for its construction. It has three pot holes for cooking. One pot hole is used for warming water, and one as an oven for baking. Provision of a chimney in this design makes the kitchen smoke free. The combustion is controlled by dampers (Salariya and Jindal, 1983). (Figure 2g).

viii. Samadhan Chulah: The Samadhan Chulah has three pot seats, with a height of approximately 2.5 cms. more than the BKT type. The placement of pot seat is not in a straight line. Plain dampers are used (Figure 2h).

C. Biogas Technology

Literature on this aspect was reviewed under the following headings:

1. Significance of Biogas Technology,
2. Process of Production of Biogas,

3. Types of Biogas Plants

and 4. Technical and Operational Problems in the use of Biogas Plants.

1. Significance of Biogas Technology

Though biogas technology has been known for a long time considerable interest has recently been generated in this direction, mainly because of the higher costs and rapid depletion of local traditional fuel sources and of fossil fuels (Mayur, 1980; Oblisamy, 1980; and Mathur *et. al* 1982). The energy needs of the rural areas can be easily met from animal, human and farm wastes.

India which has the largest cattle population in the world, offers a tremendous potential for the development of biogas. India has 19 per cent of the total world cattle population and 50 per cent of the total world buffalo population.

The Department of Science and Technology (1981) gives the following data:-

Cattle population in India	...	237 million
Average dung obtained per animal per day	...	10 kg. wetdung
Collection rate of dung	...	66 per cent of the total population.
Total availability of wet dung	...	575 million tonnes per annum.

Production of gas through the biogas plants	...	22425 million cu.m.

Parmora (1983) says that in India about 303 million MWh of energy as biogas and 368 million tonnes of manure per year can be produced through biogas plants from the available cattle dung alone.

The population of cows, buffaloes and bullocks in India is estimated to be about 250 million which produce two million tonnes of wet dung daily. It has also been estimated that about 82 per cent of the cattledung utilized as dung cake for domestic cooking in rural areas. If 50 per cent of the cattle dung produced in the country could be passed through biogas plants, it will save 15-17 million tonnes of coal (Kanawade and Ingle, 1984).

The potential sources for production of biogas are cattle dung, human excreta, poultry droppings, pigdung, excreta of other livestock (sheep, goat, camel, mule, horse etc.,) crop residues, water plants etc. The total potential available in the country for biogas production from exreta of livestock is indicated in Table III.

TABLE III

POTENTIAL BIOGAS PRODUCTION FROM LIVESTOCK EXCRETA

Source	Population (million)	Total excreta (million tonnes per annum)	Biogas production million cu.m./annum
Cattle	178.8	738	49,500
Buffalo	57.9	245	16,500
Poultry	136.8	3	500
Sheep and goat	106.6	12	1,600
Pig	6.4	2	300
Other livestock	3.3	6	800
		1,006	69,200

If all the available livestock excreta is used for biogas production the total biogas yield will be 69,200 million cu.m. per annum, which would be equivalent to 88.8 million kWh of effective electrical energy. Tam and Thanh (1983) are of the view that the potential of Biogas Technology in India is appalling, if 1,87,50,000 family size plants ($1.7m^3$ of gas/day) and 5,60,000 community plants ($142m^3$/day) are completed by 1990, biogas could supply India with an energy amount equivalent to nearly 44 per cent of its projected electricity consumption and reduce its projected consumption of coal by 15 per cent and of firewood by 79 per cent.

Although calculations about the biogas potential in the country vary, it is clear that with proper planning, the use of biogas as an alternate cooking fuel could be encouraged (Sundaresan, 1984). With the cattle population remaining steady and food grain production rising, the quantity of crop residues available per head of cattle will increase which if properly used, would improve dung production by 50 per cent. This amount of dung should be sufficient for 5,60,000 community plants of 140 cu.m. per day each one meeting the needs of 500-600 people and 1800 million family plants of 1.68 cu.m. size (Science for Villages, 1983).

Biogas technology is well known to offer fuel, fertiliser and environmental sanitation. The ultimate application of this technology in the rural areas will have far reaching effect in the rural reconstruction efforts (Biswas, 1976; Biswas, 1977; De Silva, 1979; Hammand, 1979; Rolz et.al., 1979; Aiyasamy and Kombairaju, 1980; Patel, 1980; Sharma, 1980; Thomas, 1980; Reddy, 1981; Anand, 1983; and Babu, 1983).

Biogas can be used for cooking and other direct heat applications, production of hot water, replacement of diesel for diesel engines, gas lamp with mantle, production of electrical energy and hot air for driers. The digested slurry also serve as a superior manure with its own merits. (Kamaraj, 1981; Khairoowala and Shankar, 1984; and Rajput, 1984).

The biogas programme will have a direct bearing on minimising deforestation and restore ecological balance. The benefits arising from reducing and preventing economic and environmental losses due to indiscriminate use of wood and loss of plant nutrient due to burning of dung and crop residues make it most attractive energy technology for rural areas (Johal and Shukla, 1980; Rajasekaran, 1980; Myles, 1982; Subramaniam, 1980; Patel and Patel, 1985).

The biogas programme solves the energy as well as fertiliser problem and it gives an impetus to rural hygiene and reduces the drudgery of women folk. (Ganguly, 1980; Mulmule, 1980; Rao, 1982; and Shah, 1984).

The biogas technology has great significance for formers as they obtain fuel and organic fertiliser from the same input 'dung'. The digested slurry has a 10-20 per cent higher crop yield than undigested manure. (Vimal, 1975; Johal and Saini, 1980). The study conducted by Indiravathi (1968) pointed out that the cowdung slurry as a manure proved to be superior to the other organic manures. (Table IV).

TABLE IV

NUTRIENT CONTENT OF THE FARMYARD MANURE VEGETABLE COMPOST AND COWDUNG SLURRY

Manure	Percentage on dry basis			
	Moisture	Nitrogen	Phosporic acid	Potash
Farm yard manure	15.00	1.3	1.2	2.6
Vegetable compost	10.00	0.5	0.3	0.6
Cowdung slurry	94.00	2.1	1.6	3.5

The percentage of nitrogen, phosphoric acid and potash was highest on dry weight basis in the cowdung slurry when compared to the other two manures.

The amount of manure obtained through the gas plant is 43 per cent more than pit manure. The outlet slurry is fully digested and rich in nitrogen and humus and can directly be applied in the farm (Gondhalekar, 1975; Padmanabhan, 1978; Garg, 1981; and Parmara, 1983).

Installation of biogas plants leads to advantages in terms of fertiliser thus

1. It helps in increasing the quantity of manure by 50 per cent to 60 per cent when compared to farm yard manure due to anaerobic fermentation,

2. It improves the quality of manure by 50 per cent nitrogen where as the farm yard manure consists of 0.75 per cent nitrogen where as the manure of the gas plant consists of 1.5 per cent nitrogen,

3. The manure from the plant is free from offensive odour,

4. The manure mixes with the soil easily and

5. This manure is rich in humus and improves soil characteristics, soil texture, structure, water holding capacity and prevents water logging.

Parmara (1983) estimate that if all the available cattle dung in the country is properly utilised in biogas plants 368 million tonnes of manure could be produced annually.

Biogas plant is an efficient waste treatment plant contributing to public health, since during the anaerobic digestion harmful enteric bacteria, viruses and some intestinal parasites are destroyed. The other health advantages as Chawla (1975),Saxena (1975), Mulmule (1980), Swaminathan (1980) and Myles (1982) pointed out are the following:

1. Improvement in village sanitation since digested slurry does not encourage flies and mosquitoes to breed.

2. Reduction in eye and lung diseases among women and children since the gas generated is smokeless.

3. Improvement in cooking efficiency and reduction in undesired, unwanted removal of trees for fuel purposes.

Biogas technology can eliminate the drudgery of collecting and transporting firewood which is a time consuming job. Cooking time can considerably be reduced by 2-3 hours a day. The leisure hours can lead to more productive work by women (Eggling et. al.,1980; Myles, 1982; and Tam and Thanh, 1983).

By using biogas, the house wife's work becomes much more simple and easy. The gas burns with a smokeless blue flame and gives more heat than the cowdung cake (Hazra, 1974; Chowla, 1975; Ragunath, 1974; Mulmule, 1980; Swaminathan, 1980; and Muthu, 1981). The conversion of dung into gas yields a fuel which is six times more thermally efficient than cowdung.

The smokeless blue flame of the gas has contributed to the removal of eye troubles, saving of time, lengthening of cooking utensils, maintenance of cleanliness in the kitchen and the house, better health of women, durability of clothes and better care of babies. The saving of time of the women was another advantage which could be devoted to spinning and other economic activities, thus augmenting their family income. (Moulik, 1977; Muthu and Varalakshmi, 1977; Chittaranjan, 1981; Medhi, 1982; and Roy, 1982).

Along with cowdung other organic waste such as crop residue, agricultural wastes and weed which are available in plenty in the rural areas could be used in biogas plants. The resources that can be used for producing biogas are cowdung,human excreta, poultry droppings agricultural wastes such as straw, plant leaves, algae, bagasse, ground nut shells, paddy husk etc. Apart from these wastes, cellulosic organic matter, wastes from tanneries,food, industries, paper mills can also be used for the production of biogas (Sharma, 1976; Khan, 1977; Majumdar, 1978; Ganguly, 1980; Ghose, 1980; and Patil, 1980). Night soil, the organic waste also could be utilised for the production of biogas. (Subramanya and Ganesh, 1974; and Muthu and Madhavi, 1977). The use of farm wastes and other wastes through gobar gas is now accepted by the village communities on a substantial scale (Soni and Patel, 1984).

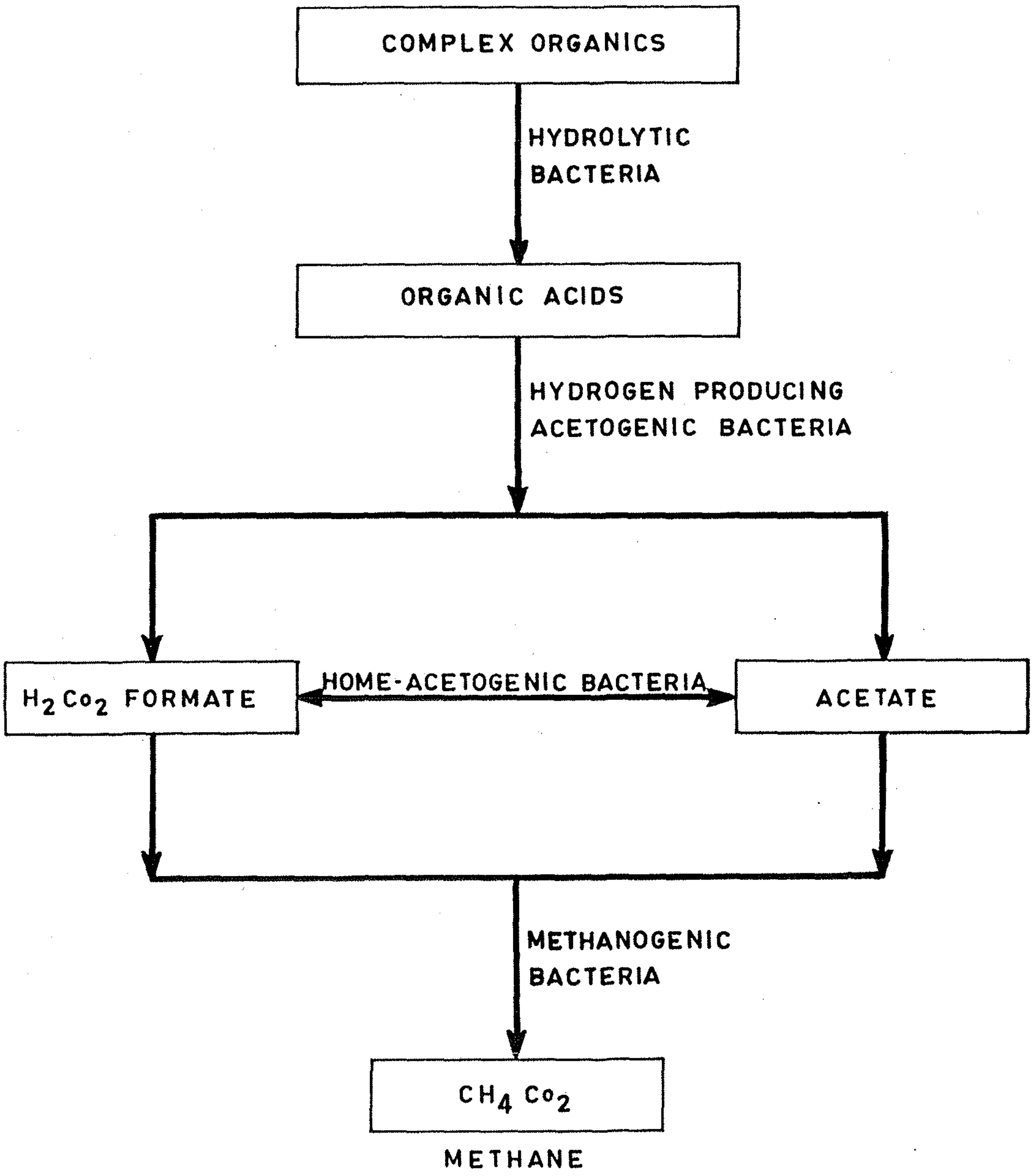
The studies conducted at Sri Avinashilingam Home Science College, Coimbatore, by Geetha (1979), Rajani Devi (1979), Ajitha (1980), Selvi (1980) and Gnanambal (1981) indicated the possibilities of using garbage and vegetable wastes such as greens, snake gourd, plantain, onion and pumpkin peels, yam, cabbage and beetroot, banana stem, banana leaves and babana peels, ground nut husk, rice straw, cholam stalk and water hyacinth for producing gas. It was proved that garbage in combination with cowdung would yield more biogas. The installation of biogas plants also helps in providing employment to skilled and semiskilled artisans and educated unemployed (Patel, 1980).

2. Process of Production of Biogas

Biogas is a product of anaerobic fermentation of organic matters such as cowdung, night soil, poultry droppings pig manure etc., and consists of about 60 to 70 per cent methane, 30 to 40 per cent Co_2 and small amounts of other gases (Palanisamy, 1981; Myles, 1982; Tam and Thanh, 1983). Biogas burns with a blue flame. It has a heat value of about 500-700 BTU/ft^3 (4500-6300 $kcals/m^3$) when its methane content ranges from 60-70 per cent. The value is directly proportional to the amount of methane it contains, and this depends upon the nature of raw materials used in the digestion.

The complete anaerobic fermentation process is depicted in Figure 3. Four groups of bacteria are responsible for the fermentation. They are described below:

a. Hydrolytic bacteria - These stabilize carbohydrates, proteins, lipids and other minor components of biomass to fatty acids, H_2 Co_2.



BIOGAS PRODUCTION PROCESS

FIGURE 3

b. Hydrogen producing acetogenic bacteria which catabolyze certain fatty acids and several end products to acetate H_2 and Co_2.

c. Home actogenenic bacteria - which synthesised acetate using H_2, Co_2 and hydrolyse multi carbon compounds to acetic acid.

d. Methanogenic bacteria which utilise acetate, H_2 and Co_2 to produce methane.

The evaluation of biogas appears to be controlled by a number of environmental factors such as nature of materials, temperature, solid concentration carbon nitrogen ratio, pH range, and period of detention (Gupta, 1977).

a. Nature of raw materials

The amount of methane produced bears a direct relationship to the raw materials used for digestion (Johal and Saini, 1980; and Dahiya et. al., 1982). Biswas (1977) points out that addition of simple energy materials such as urea, sugar, poultry excreta and cattle urine are helpful, since fermentation and microbial growth depend upon optimal supply of nutrients. The material which are rich in cellulose and hemicellulose produce more gas, at the same time purely proteinaceous material produce low gas (Myles, 1982).

b. Temperature

The optimum temperature range for biogas production is 30 - 35^{o}C, though the micro-organisms producing methane can work, in a wider range of temperature from 15^{o}-50^{o}C. If it is lower or tends to fluctuate, gas production will drop severely (Warner and Chawla, 1981).

c. Solid concentration

Parmora (1983) views that the gas generation from biogas plant is dependent upon the concentration of solids in the influent slurry. Seven to nine per cent of the total solids concentration in the slurry, causes optimum gas production.

d. C/N ratio

Parikh and Kakalia (1978) point out that the carbon and nitrogen ratio is the main factor in digestion. Sathianathan (1975) remarks that the bacteria need both carbon and nitrogen in the proper ratio as carbon content is important for high yield of methane and nitrogen is required for the growth of bacteria. The ratio of carbon to nitrogen (C/N ratio) by weight should be about 30:1, as bacteria use up carbon 30 times faster than they use nitrogen.

e. pH

The bacteria perform best in neutral to slightly alkaline media. The pH optimum has generally been found to occur between 6.7 - 7.4 and pH values below 6 or above

8 are very destractive as indicated by Kapur (1980) and Myles (1982).

f. Detention period

The detention period is the time for which the fermentable material stays inside the digestor. Patel (1980) observed that in India, using mainly continuous feeding the detention period of 50 to 60 days is required for optimum gas production.

g. Toxic Substances

Ragunath (1974) reports that adding the residues of crops that have been treated heavily with organic pesticides and other chlorinated hydrocarbon may inhibit the gas production. The bacteria can easily be poisoned by adding too much of soap, acid, or other chemicals which automatically retard the gas production (Warner, 1981).

Among the different parameters the temperature is the most difficult to control. The process stops when the temperature drops below 10^{o}C. This is a major technical constraint for the cold regions. Waste materials such as cattle, sheep and horse dung have a C/N ratio near the optimum value but human exreta and poultry waste have a low C/N ratio and these sources should be mixed with materials of plant origin to bring the C/N ratio to an optimum level.

The longer the time, the larger is the volume of gas produced from a given amount of waste.

3. Types of Biogas Plants

The biogas plant is an air tight container which facilitates fermentation of organic materials under anaerobic conditions. With the emphasis on biogas much experimentation is going on in different parts of the country to design plants which would be more efficient and be acceptable to small farmers.

Myles (1982) classifies the biogas plant designs as follows:

Common Designs of Biogas Plants

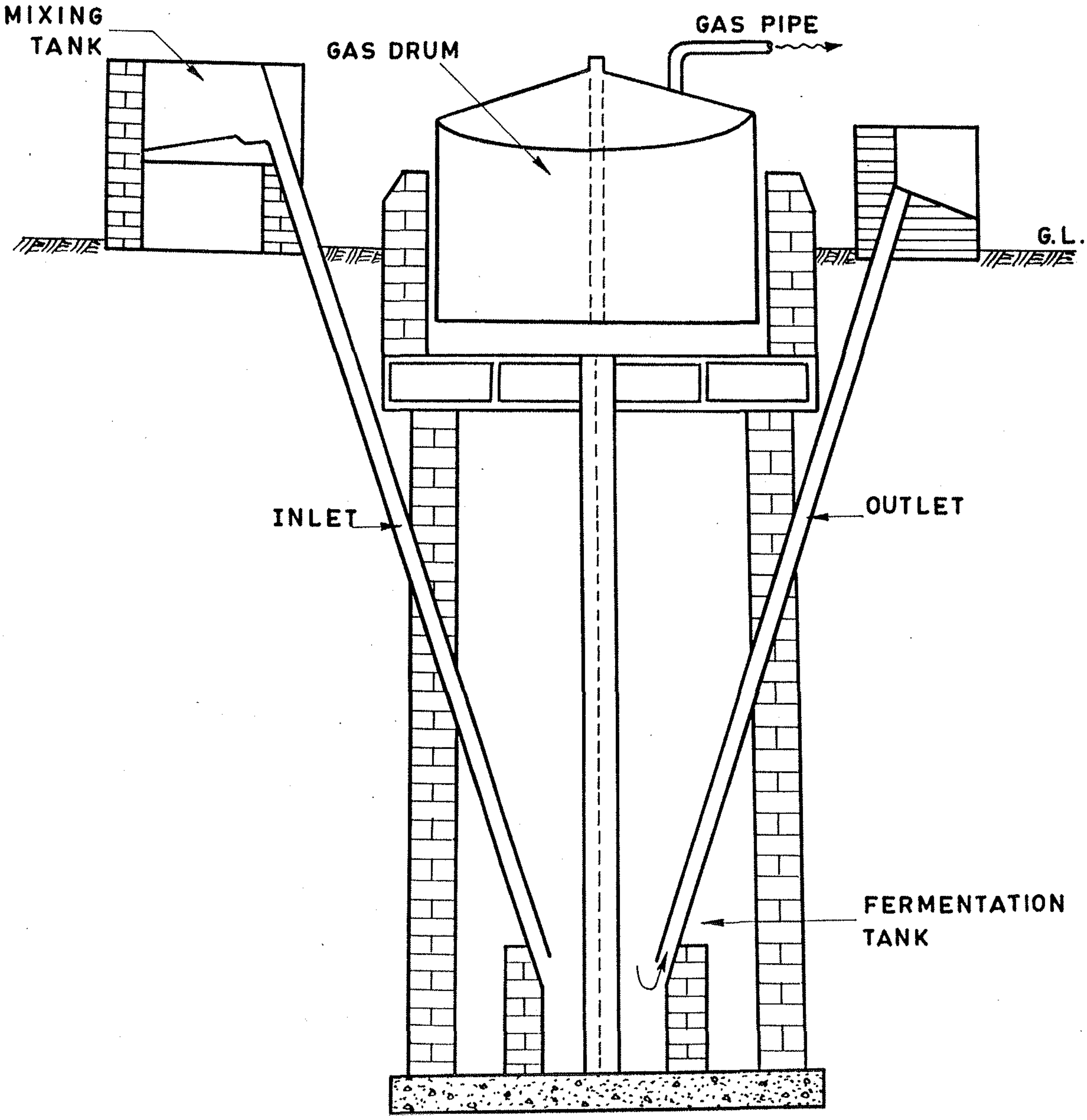
Movable gas holder plant	Fixed Dome Plant	Digester and gas holder separate	Flexible bag plant
Khadi and Village Industries Commission (KVIC Design)	'Sichuan'	Jar type	Neuprene bag
Indian Agricultural Research Institute (IARI Design)	'Shanghai'	Borda model	Red mud plastic
Planning Research and Action Institute (PRAI Design)	'Janata' (Brick masonry)	Garbage plant (ARTC Pardoli)	
Application of Science and Technology to Rural Areas (ASTRA model)	'Bhagyalakshmi' (partition wall)		
	'Kalinga' (RCC)		
Murugappa Chettiar Research Centre (MCRC) JWALA	ASTRA (Chinese type)		
	Gujarat (ATRC, Agro)		
	Bardoli (RCC, segment)		
	Horizontal RCC pipe		
	AFPRO (Action for Food Production)		

The Department of Science and Technology (1981) describes six biogas plant designs available in the country evolved by the following organisations:

1. Khadi and Village Industries Commission (KVIC).
2. Planning Research and Action Division (PRAD).
3. AMM Murugappa Chettiar Research Centre, Madras (MCRC).
4. Tamil Nadu Agricultural University, Coimbatore (TNAU).
5. Indian Agricultural Research Institute (IARI).
6. Cell for Application of Science and Technology to Rural Areas - Indian Institute of Science, Bangalore (ASTRA).

1. Khadi and Village Industries Commission (KVIC) - Biogas plant with movable gas holder

This is one of the most common designs presently in operation in India. Figure 4 shows the design. It has a movable cylindrical gas holder on top of the well shaped digester. The biogas produced in the digester due to anaerobic fermentation rises vertically it being lighter than air and gets accumulated in the gas holder. The gas is stored in the holder at a pressure of 8-12 cm. of water column. This much pressure is more than enough to convey the gas to a distance of 50-100 metres, when the valve is opened. The gas holder is designed to store approximately 50 per cent of the daily gas production. Therefore, if the



K.V.I.C. GOBAR GAS PLANT

FIGURE 4

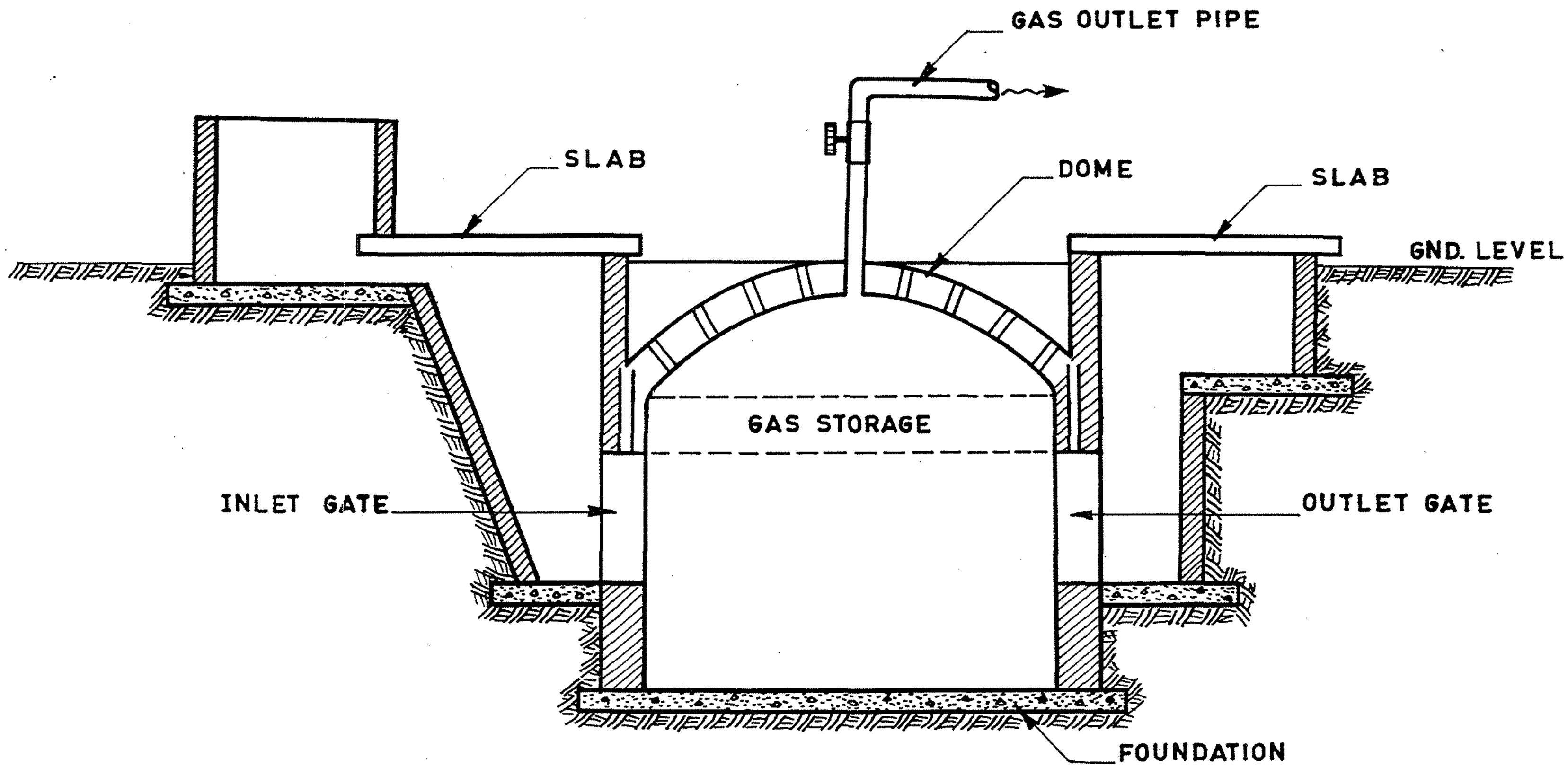
gas is not used regularly, then the extra gas will bubble out from the sides of the drum over the water. This plant is considered most ideal for continuous flow digestion.

2. Planning Research and Action Division (Fixed Dome Biogas Plant)

The fixed dome giester is commonly known as the 'Chinese digester'. This can digest plant waste as well as human and animal wastes. It is usually built below the ground level, making it easier to insulate in cold climate. The gas holder is an integral part of the digester. Being a fixed dome, the pressure is variable, varying from 0 to 150 cm. of water column. Special skills are required for its construction. In India, a modified fixed dome plant has been developed to work as continuous flow digester and is commonly known as the 'Janata (people's) plant'. While the Chinese plants have more holes provided on the top for occasional clearing of sludge and digested material, the Janata plant has a completely closed top and the digested material in the form of spent slurry goes out automatically from the outlet chamber (Figure 5).

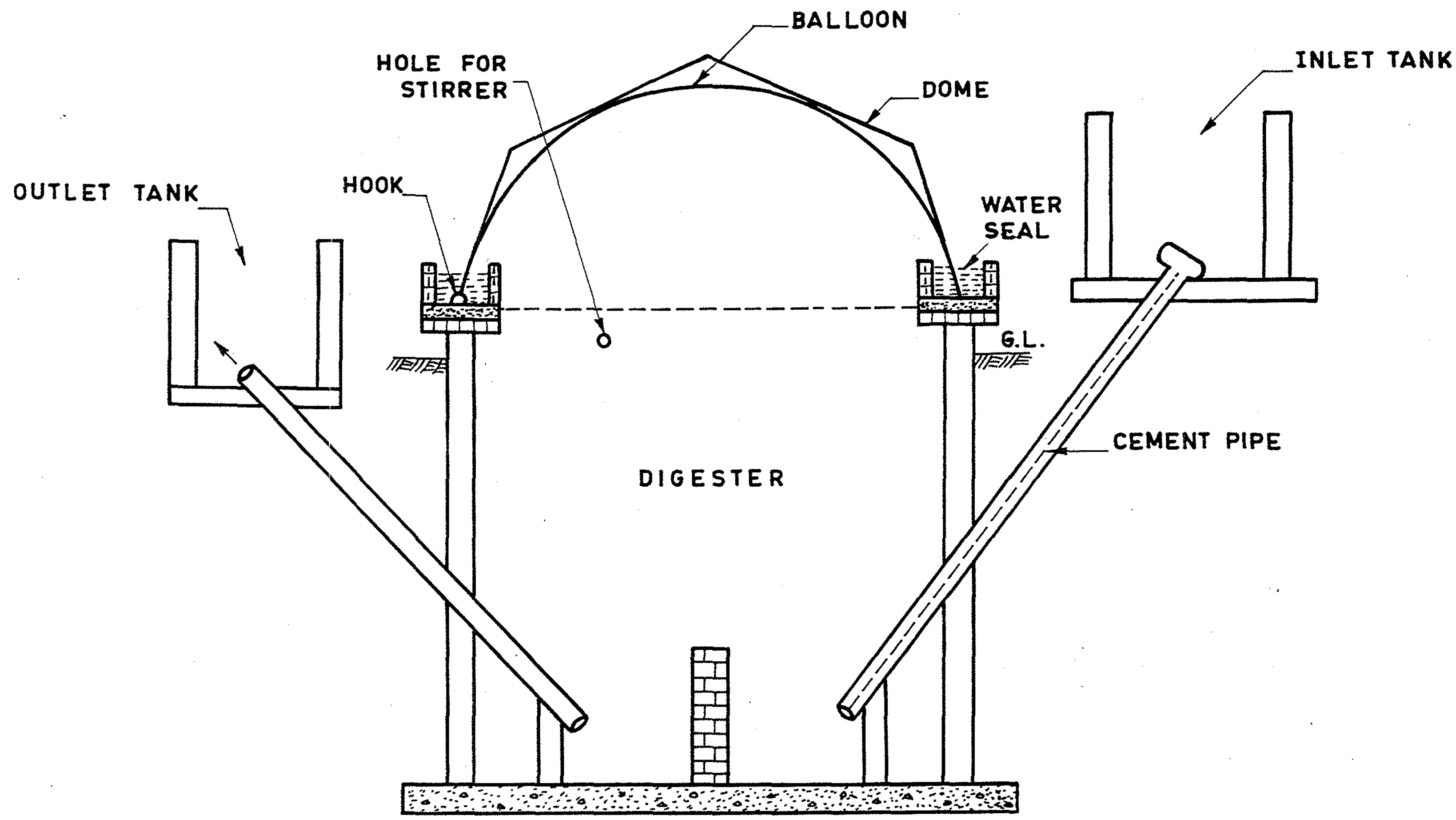
3. Murugappa Chettiar Research Centre, (MCRC) Madras ('JWALA' biogas plant)

The 'JWALA' biogas concept of MCRC uses a Low Density Poly Ethylene (LDPE) geodesic baloon as a storage element (Figure 6). The 'Jwala' design is an attempt to



JANATA BIOGAS PLANT

FIGURE 5



'JWALA' - IMPROVED BIOGAS PLANT

FIGURE 6

hybridise the good features of the Indian and Chinese designs. It is a closed type variable pressure plant with a divider wall similar to the one used by the KVIC. The PVC dome is used to collect the gas and provides a large dead space. The off take of gas is possible only when a positive pressure develops after the PVC rises to its full extent. It also appears that the space for the displacement of slurry is too small. Umesh and Seshadri (1981) narrate the specific advantages of the 'JWALA' design as

- It is least expensive.
- It can be fabricated locally.
- It can be constructed even by men with average skills.
- The baloon material can be carried to any remote place in a small bag.
- The gas holder is easily removable and replaceable for cleaning purposes.
- The LDPE sheet for gas holder solves many problems encountered in other designs. For example, painting of the mild steel drum in the KVIC design or the requirement of highly skilled, personnel to construct a gas proof masonry dome in the Chinese design are totally eliminated in this design.

4. Tamil Nadu Agricultural University, Coimbatore (TNAU)

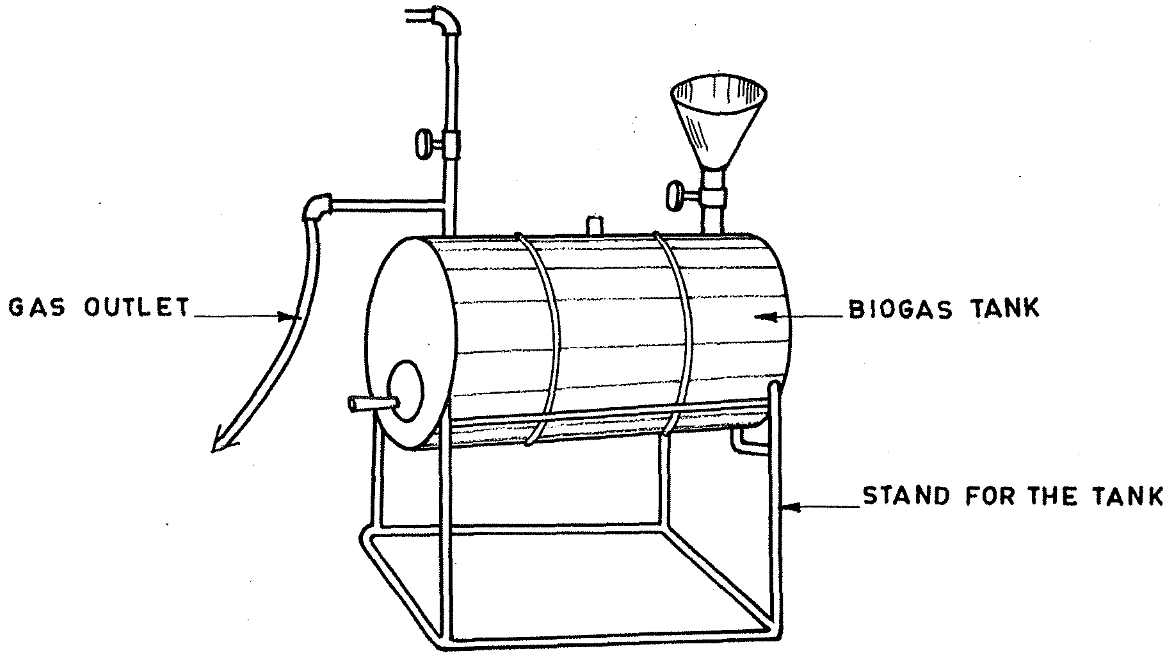
To alleviate some of the problems encountered by the conventional units such as rusting of the gas holder, choking and drying up the digester, marked fall in gas production in winter, static structure involving excavation of soil and spoilage in masonry construction involving brick, cement, and labour and problems in slurry disposal as the structure is below ground level, the TNAU designed a Mobile Biogas plant of cylindrical and cubical shape.

a. Cyclindrical

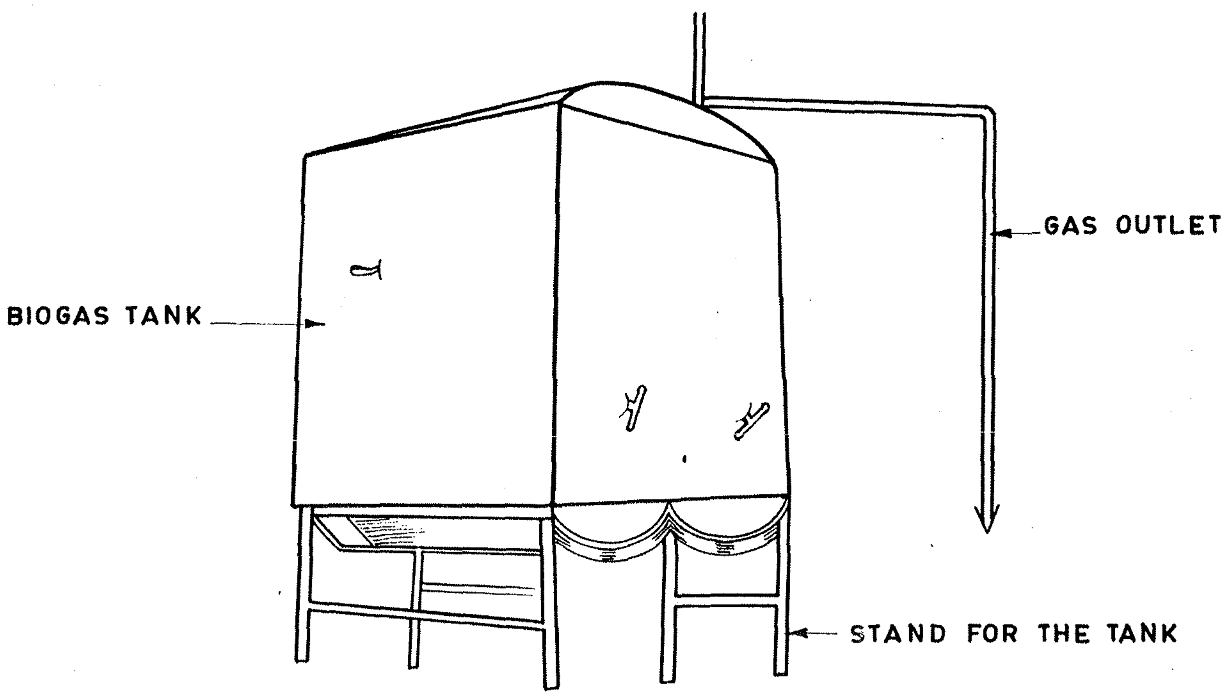
An oil drum is taken in which three holes are made two at the top and one at the bottom. At one of the top holes, a funnel is fixed to feed an influent slurry. A gate valve is fitted beneath the funnel to close the opening. A gate valve is attached to the other hole to regulate the gas. The effluent slurry can be removed through the bottom hole which is closed with a lid. A stirrer is fixed at the other end of the drum to mix cowdung with water (Figure 7a).

b. Cubical

Ten gauze galvanised iron sheet is used to design a cubical, shape mobile biogas plant. Upto 2/3 height from the bottom, a partition wall made of iron sheet is fixed in the middle. Each compartment has the capacity of 400 gallons. In one compartment, a tube is fixed to feed cowdung and water and at the other end, 15 cm. below this



(a) CYLINDRICAL MODEL (T.N.A.U.)



(b) CUBICAL MODEL (T.N.A.U)

FIGURE 7

tube height, another tube is fixed to remove the spent slurry. At the top of the plant, the pipe line is fixed. To clean the plant, two exit tubes are fixed at the bottom. For each compartment, a stirrer is fixed to mix the slurry (Figure 7b).

5. Indian Agricultural Research Institute (IARI) Model

This is similar to the KVIC and appears to have been used only at few places in Delhi.

6. The ASTRA Design

This is a modification of the KVIC design, with a lower retention period (35 days) and with the dimensions of the digester and the gas holder optimized for minimum cost. Forty per cent of cost could be saved in constructing this type over the KVIC model.

Several innovations have been made in the design of biogas plants to suit the area and to bring down the cost of construction. Two such designs are described here.

KERAGRI - HORIZONTAL Type Biogas Plant

A horizontal type biogas plant has been developed by the Department of Agriculture (Nodal Department of Kerala Biogas Development) exclusively for high water table areas, water logged locations, and areas even below sea level like

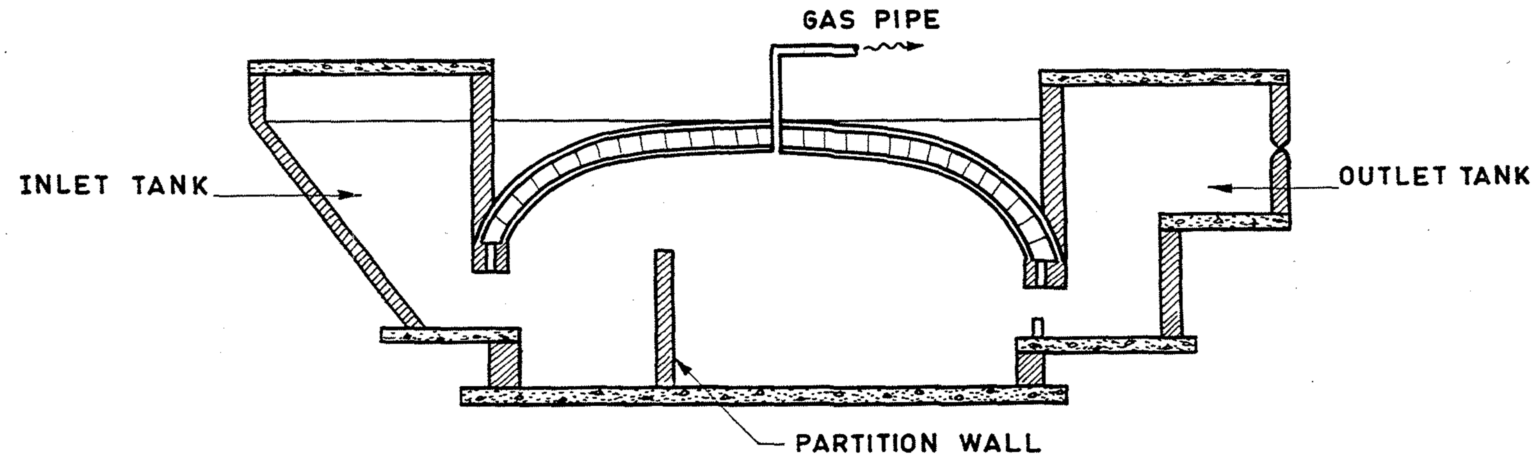
Kuttanad (Figure 8). The earth column in such area is so thin that a biogas plant of the conventional Dome (Janatha) or Drum (KVIC) type is difficult to construct and has also proved unacceptable to the cultivators.

The new model requires relatively lesser depth. Covering of the dome part with earth, will not create problems nor these need be any fear of sinkage.

At the outer opening, a concrete slab is fixed for maintaining the necessary gas production volume for the methanogenic action. The partition is at a distance of one-third the length of the digester length from the inlet opening to facilitate and complete acid and hydrolysis phases. In the partition wall it is proposed to give a removable slab of one inch thickness in the centre portion, so that it can be removed in case of necessity. Inlet and outlet tanks are also given sufficient volume to accommodate the slurry rise due to the pressure of gas produced inside the digester chamber. (Panicker, et. al., 1985).

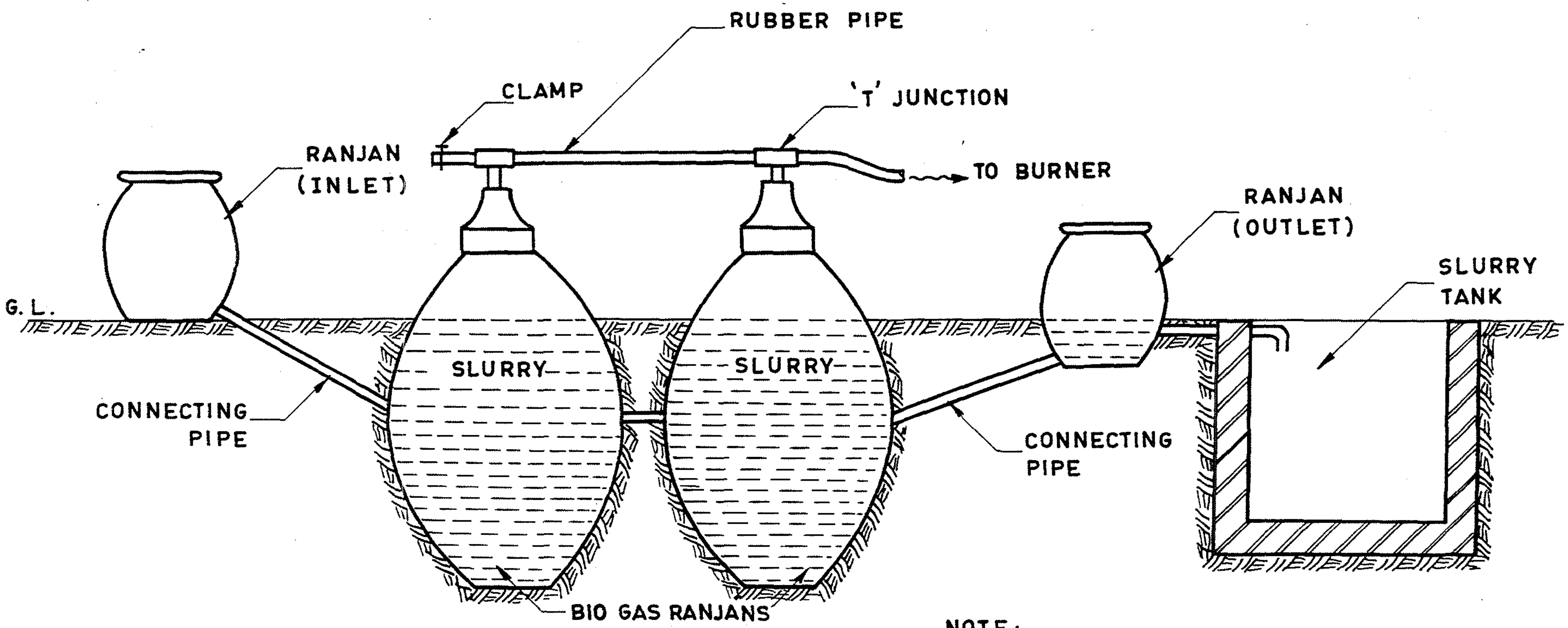
Ranjan (Mud-jar) biogas plant

The centre of Science for Villages Wardha has developed a low cost biogas plant known as Ranjan (Mud-jar) biogas plant (Figure 9). The plant costing one fourth of the traditional ones, has been designed for the requirement of a family of five. The plant is a battery of 8 to 10 Mud-jars



'KERAGRI' HORIZONTAL TYPE BIOGAS PLANT

FIGURE 8



NOTE: 'RANJAN' IS A LOCAL WORD FOR LARGE SIZED MUD JAR

'RANJAN' BIOGAS PLANT

FIGURE 9

of 300 to 400 litre capacity. It has to be fed with 40 kg. of cowdung mixed with an equal amount of water per day. The first and the last mud pots are connected with smaller mud-jars for entry and exit of the cowdung slurry. These are placed at the ground level, while the bigger jars are embedded with three fourth of their height below the ground level. The jars are closed at the top and fitted with a 'T' tube to connect rubber tubing for gas transfer at the middle height of the jar. The slurry movement is inter connected with mud pipes of 3 inch diameters. All the components of this plant except the tubing can be produced by the villages potter and the assemblage done without the help of the mason. The plant can produce 50 cubic feet of gas which is sufficient for cooking on one gas burner for about four hours. It costs only Rs:600/- (Science for Villages, 1981).

4. Technical and Operational problems in the use of Biogas plants

The most frequent technical problems were corrosion of gas holders and pipelines owing to rust, seasonality of gas output, frequent break down of the central guide pipe and bursting of the hose pipe, cracking of digester wall, formation of scums, hindering the release of the gas holder, choking of inlets and outlets of gas plants resulting in disturbances to the flow of gas, accumulation of water in pipe line and non availability of the optimum level of water and dung resulting in improper loading of the digester and reduced efficiency (Patel, 1977).

Singh (1981) indicates that the primary reason for the failure of KVIC design arises from the fact that biogas contains small quantities of hydrogen sulphide ammonia which corrodes the metallic gas holder causing gas leakage. Further as Nagar (1976) states the digester cover is usually made of steel and corrodes easily as it it is in constant contact with the toxic substances present in the atmosphere and in the slurry. Alternate materials like fibre glass, ferrocement, galvanished iron and plastics or high density polythene, glass reinforced polyster sheets etc., may be used as substituted materials for the gas holder. Ferrocement, reinforced polyster, treated wood, plywood, plastic polythene with bamboo basket reinforcement etc., have been tried for the gas holders. But none has proved to be a suitable replacement for mild steel.

KVIC has suggested both mechanical and chemical treatments to partially overcome the problem of corrosion. In mechanical treatment, daily cleaning of scum around the holder is suggested. Whereas the chemical treatment involves coating of synthetic enamels. This leads to an increased maintenance cost (Sathianathan, 1975).

Biswas (1977) states the non availability of appropriate and efficient designs of biogas burners and lamps is a major constrain in biogas utilisation. Because of low pressure the distribution of gas to distant sites poses problems. House made burners lead to inefficient use and more consumption of gas.

Verma (1978) mentions the problems of heavy gas reduction or sometimes even no gas production due to low temperature at northern region. Patel (1977)and Venkatappa et. al. (1981) state that the mal nutrition of the cattle has been the major constraint adversely affecting the quality as well as the quantity of the dung.

The socio economic problems faced are prohibitive cost of plant and cattle requirement for the poorest section, lack of backyard space owing to the residential pattern in villages, difficulty in dung collection because cattle are geared in open areas rather than in fenced areas, lack of water sources near the plant and difficulty in connecting latrines with the plant because of their being away from the home (Patel, 1977).

Rajput (1984) gives an elaborate list of operational problems, their causes and remedies. They are given below.

COMMON PROBLEMS IN BIOGAS PLANTS AND THEIR REMEDIES

S.No.	Problem	Cause	Remedies
	INSTALLATION		
1.	Digester wall cracks	Improper back filling or sinking of the foundation	Carry out proper backfilling and repair
2.	Leakage of gas	Improper construction of dome	Locate the fault by thorough checking and repair
3.	Water accumulation in pipe	Water tap not installed at the proper place/ position	After checking the levels, install the water tap at the right place; pour out water periodically
4.	Non-availability of gas after filling of plant	Lack of time	Relax and give adequate time. It may take 3 to 4 weeks.
	OPERATION		
1.	First gas produced does not burn	i. Wrong kind of gas with too much carbon-di-oxide	i. The gas may be let to escape for some time
		ii. The gas pipe may have air	ii. Allow air to go, close it when a definite smell of gas comes
2.	Slurry level does not rise in inlet and outlet chambers	i. Inadequate slurry	i. Add more slurry
		ii. Formation of hard scum	ii. Agitate with a bamboo pole (or) rod

S.No.	Problem	Cause	Remedies
3.	Very slow pressure rise	i. Too low temperature	i. The temperature of slurry may be low in winter. Improve temperature by addition of hot water for slurry preparation
		ii. Formation of thick scum on the top of slurry	ii. Agitate the slurry daily
		iii. Daily addition of slurry either too much or too little	iii. Always use correct amount of slurry
		iv. Slurry too thick or too thin	iv. Prepare the slurry of right consistency. Mix dung with water in the ratio 1:1 properly
		v. Addition of chemicals like oil, soap, or detergent into the slurry	v. Do not allow chemicals like oil, soap or detergent into the slurry
		vi. Gas may be leaking	vi. Locate and repair the leaks
4.	No gas at stove	i. Main gas valve closed	i. Open the main gas valve
		ii. Condensate completely blocking the main gas pipe	ii. Disconnect the stove clean the gas jet with the needle, taking care not to enlarge or damage the jet
		iii. Gas jet in stove blocked	

S.No.	Problem	Cause	Remedies
5.	Small flames	i. Gas jet in the stove may be partially blocked	i. Open the gas jet
		ii. Inadequate gas production	ii. Break the scum formed in the digester by agitating the slurry
		iii. Flame parts partially blocked	iii. Clean the flame parts after regular intervals
6.	Pulsating flame	i. Presence of condensate in the main pipe	i. Remove the condensate Pulsating flame indicate water still lying in the pipe which can not be drained out. For this lay the pipe at a slope of 1 in 100 while installing the plant.
		ii. Presence of condensate inside the pipe	ii. Remove the condensate by turning stove upside down.

This knowledge is essential to forecast the various detrimental factors and guide the people desirous of adopting biogas technology.

D. Solar Energy for Household Purposes

This part of the review consists of the following headings:

1. Significance of Solar Energy,
2. Solar Devices for Household use

and 3. Constraints in Using Solar Energy.

1. Significance of Solar Energy

'Let the world focus its constant attention at the centre of the planetary system where the Sun, the supreme power of the universe resides' (Rig Veda).

The idea of utilisation of solar energy is not new. In 212 BC, Archimedes set fire to the Roman fleet by concentrating the sun's rays on the ship using hundreds of mirrors. Solar energy production by fusion reaction was first suggested by Atkinson and Houserman in the year 1929, Later in the year 1939, Bathe, gave an alternative method of obtaining fusion energy (Ramaraju, 1978; and Devanathan, 1979). The Encyclopaedia Britannica of Energy (1976) defines solar energy as that energy transmitted from the sun in the form of electromagnetic radiation.

Venkatesan (1978) states that right from the origin of the solar system, the sun has dominated the scene and played a central role in activating life on earth. The ancients in India considered the sun as the creator, sustainer and destroyer of life on earth (Clark, 1977; and Sethna, 1972). Sun is the primary source of all forms of energy on the planet (Khan, 1974).

Solar energy which is available in plenty, is the oldest form of energy and the most important answer to the present energy problems facing the world. (Bhusan, 1977; and Kapur, 1979). The sun is an unlimited source of power and has inexhaustible resource of energy, which will last as long as the solar system exists (Daniels, 1974; Gupta, 1978; and Narayandas, 1980). Unlike finite fuels, sunlight is a flow and not a stock (Hogan, 1978; and Nadkarne, 1979).

Since the beginning of this planet earth the sun has given nearly all the energy needed. The sun supplies 20,000 times as much energy as man consumes from all sources (Bhide, 1978; and Devadas, 1980). Among the major energy sources available, solar energy is basic to man's very survival on earth. It satisfies three important requirements of any energy source. (i) It is plentiful, (ii) potentially inexpensive and (iii) its utilisation has little impact on environment. (Kurusunogalu, 1974; Kiely, 1979; Venkateswaran, 1979; Broda, 1980; and Rao, 1983).

Solar energy is one of the time dependent and intermittent energy resources. This renewable source of energy is available directly from the sun in the form of radiant energy. It is available indirectly, in the form of stored energy in biomass, heated water, hydropower and wind energy (Miller, 1983; and Nair, 1984). Solar energy is available abundantly and freely during the day time.

Though the sun is at a distance of 149 million kilometres from the earth it takes only 8 minutes to travel the distance since the velocity of light wave is 3 x 10^5 kilometers per second. The intensity of the beam is 1.94 cals/sq.cm/min. This value of solar radiation is equal to 1359 watts/sq.m. This value of solar radiation outside the atmosphere is known as solar constant. This constant can be evaluated at any desired place by experimental methods. An open area receives about 601 kcals. of solar heat per square metre in one sunny hour. This is almost equivalent to the burning of 100 gm. of coal (Ramaraju, 1978).

The solar radiation reaching the earth's land surface annually is equivalent to 0.26 x 10^{18} kWh compared to the present world power consumption of only 4.9 x 10^{13} kWh. Hence it is obvious that solar energy can meet not only the present but even all the future energy requirements of the world (Datta, 1974).

According to Bhide (1978) and Rajiva and Vats (1979), the total annual incidence of solar energy in India is of the order of 6×10^{17} kWh. Vasudevan (1982) mentions that the amount of energy reaching the upper atmosphere in a year is 5×10^{23}J. But only 40 per cent reach the ground, which is ten-fold the known fossil fuels reserves, the rest being reflected, scattered or absorbed. As stated by Khan (1974), the earth receives about 1,311 trillion (10^{18}) kilocalories of energy annually from the sun. There is an abundance of free energy left, roughly one kilowatt per square meter on the earth's surface, which is much greater than any of man's foreseeable energy needs. It has been estimated that every square kilometer of the equatorial line on the earth receives every year approximately 1.5×10^{9} kWh of incident solar energy (Kapur, 1982). As per an estimate, this everlasting energy will satisfy man's current energy needs for nearly 7000 years.(Vasudevan, 1982).

Nair (1984) points out that solar power is abundantly available even in regions remote from the source of fossil fuels. It is essentially a nondepletable source of energy in comparison with fossil fuels and nuclear fission power and it is cost free in its original radiation form. The need for transporting the energy is avoided, if solar energy is utilised locally. Solar devices hold promise for the developing world as well as for the economically developed world. Since solar power burns no fuel, it causes no air pollution.

India receives substantial quantities of solar radiation. The number of sunny days in the year is high. The annual average intensity of solar radiation in India is 600 calories/cm^2/day. The solar radiation in several cities in India as given by National Committee on Science and Technology is given in Appendix I. The maximum, minimum and average solar radiation in some locations of India are given in Table V (Manorama year book 1983).

TABLE V

AVERAGE SOLAR RADIATION IN SOME LOCATIONS OF INDIA

STATION	SOLAR RADIATION Cals/ sq.cm/day		
	Max.	Min.	Average
Madras	765	606	720
Bangalore	746	562	668
Bombay	795	542	701
Calcutta	817	501	681
Delhi	827	421	655
Srinagar	738	239	631

The minimum radiation occurs in December and for most locations it is about 500 cals/ sq.cm/day. The intensity and distribution of solar energy are favourable for its use in India.

Even if a minimum of 10 per cent of the total solar energy received is properly harnessed, the energy requirements of all nations could be met, by the year 2001 AD (Rele, 1978). Though identified as the earliest source of energy by man, solar energy is the least exploited so far (Paul, 1977).

In most part of the country in India there are between 250-300 days of useful sunshine per year. The Indian subcontinent receives 3300-3700 hours of bright sun shine in a year working out to an average of 7-10 hours per day, showing the enormous potential of utilising the solar energy (Shanmugam et. al.,1984).

Ironically when there is abundance of solar energy, the whole world, particularly in India, why is there the grim of energy crisis?. The energy crisis affects the developing countries seriously because they need energy not to keep themselves in any luxury but to give the people the basic minimum. The increasing demand for energy, escalating oil price, fast depletion of fossil fuels, unchecked deforestation and exponential population growth have directed the attention of scientists, technologists, economists and administrators to concentrate on developing alternate energy resources that are low cost and pollution free. Solar energy meets these requirements (Spears, 1978; and Jayaraman, 1984).

This renewable, non polluting energy source is so pervasive and diffusive that it can be harnessed most economically on a small scale to meet the needs of individual families (Batra, 1977). In the wake of the energy crisis, therefore, solar energy seem to be the most promising source to meet the energy requirements (Veziroglu, 1976; Bhattacharya, 1983; Rao, 1980; Peter and Alikhan, 1984). The utilisation of eternal sunlight will help to improve the standard of living of families by reducing their expenditure on fuel (Devadas, 1980).

In India the household sector alone consumes about 11 per cent of the total energy consumption, out of which, cooking energy demands a major share. The conventional energy sources such as firewood, dry vegetable wastes and cowdung cakes are most used by the rural sector for cooking purposes. But biomass has been put recently to many other conversion possibilities. These have led to domestic fuel crisis in the country. Scientists prophesy that utilising solar energy for cooking can solve this problem to some extent (Alvim and Alvim, 1980; and Sharma, 1984). According to Gupta (1974), Culham (1975) and Pichai (1984) solar energy shows promise of becoming a dependable energy source without new requirements of highly technical and specialised nature for its wide spread utilization.

Devadas (1980), Meena (1982) and Bose (1983) have pointed out that solar energy offers a practical solution for the household energy problem which is clouding the prospects of humanity. According to Behrman (1979) and Mannan (1981) solar energy can make a substantial contribution towards fuel needs required for cooking.

The non polluting ecological nature of solar energy, its abudance and availability at the point of use, are factors particularly relevant to the current search for newer sources of energy (Mc Veigh, 1977; Paul, 1977; Thiayagarajan, 1980; Garg and Bandyopadhyay, 1981). According to Venkatasubramanian (1983), solar energy is an imperative source with an average intensity of 450 cal per sq.cm. per day. This inexhaustible and pollution free energy is the best and ready alternative to domestic fuel, if harnessed through solar cooking devices. Solar energy could be a boon for Indian villages particularly the ones situated away from the industrial centres. Pumping irrigation water, drying and processing agricultural products, producing potable water from brackish water, cooking, lighting and entertainment are some of the important fields of solar energy applications for rural areas, which need to be given priority in the developmental efforts (Garg, 1977; Kreider and Kreith, 1977; Kothandaraman, 1980; Til, 1982; and Mathur et. al., 1983).

2. Solar Devices for Household Use

There are many gadgets to trap and utilise solar energy. Some devices are directly using the solar radiation to heat the water and cook food stuffs. Some devices are converting heat energy into mechanical energy, for performing certain useful domestic and industrial services. The conversion of solar energy is possible through the

- Use of low grade thermal devices which use heat from the sun.
- Direct conversion of solar energy into electrical energy.
- Bio Chemical conversion of solar energy into transportable fuels. (Mannan, 1981).

Pichai (1984) list out the viable applications of the solar energy as,

a) Strengthening and improving the knowledge of climatic factors in the various regions through better use of water and sunlight using pumping and distillation equipment,

b) Storage and preservation of agricultural produce using solar drying, cooking or refrigeration equipment,

c) Development of fisheries using solar drying and refrigeration, and

d) Development of food technology using new techniques in processing the food and agricultural produce via rural industries employing solar heating or cooling and power units.

Thus broadly speaking solar energy could be used for

a) Domestic purposes and

b) Commercial and industrial activities.

a. Solar Cookers

Solar cooking is a technique designed to deliver solar heat to foods, for the purpose of raising the temperature and causing to cook (Halchy, 1963). Solar cooking is a science as well as an art which is to be mastered by experience.

The basic difference between conventional cooking and solar cooking is that in the former the heat is transferred to the whole mass of food by convention currents. In solar cooker the heat is supplied from the top of the cooking utensil. This heat is conducted to the utensil and thereby to the food material. Very less heat is transferred from the absorber tray to the bottom of the utensil (Vaithilingam, 1984).

There is no need for fuel collection or lighting, and safety is assured. The solar oven uses metallic wings to reflect sunshine through a double glass cover into an insulated and blackened box. If the oven is kept pointed towards the sun during the midday hours, the interior temperature attains readily a temperature over 100°C which is considered adequate for cooking operations (Bhide, 1978; Department of Commerce, Government of India, 1980; and Rai, 1980).

Several types of solar cooking devices for food preparation are available in India and in other countries. However its usefulness depends upon the availability of sunlight, the angle of solar radiation, atmospheric dust and moisture and the actual number of days of sunshine.

Thiruvengadam and Ramamoorthy (1983) mention that there are three common types of solar cookers:-

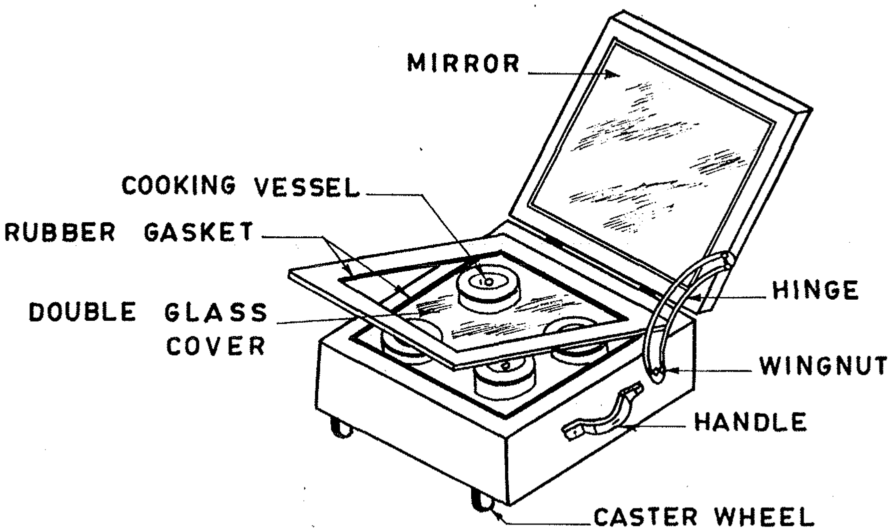
1. Direct concentration type of solar cooker where the cooking pot is placed at the focal point.
2. Indirect type of solar cooker, where the radiation after reflection enters into an insulated box in which the cooking pot is placed.
3. Advanced solar cookers where the heat from the focal point is transferred from elsewhere.

Sankaranarayanan et.al. (1983) and Meena (1984) points out that in India efforts have concentrated on three main types of solar cookers namely simple hot box type cooker, oven type cooker and a cooker based on concentrating solar radiation by paraboloid mirror reflector which directly heats the cooking vessel.

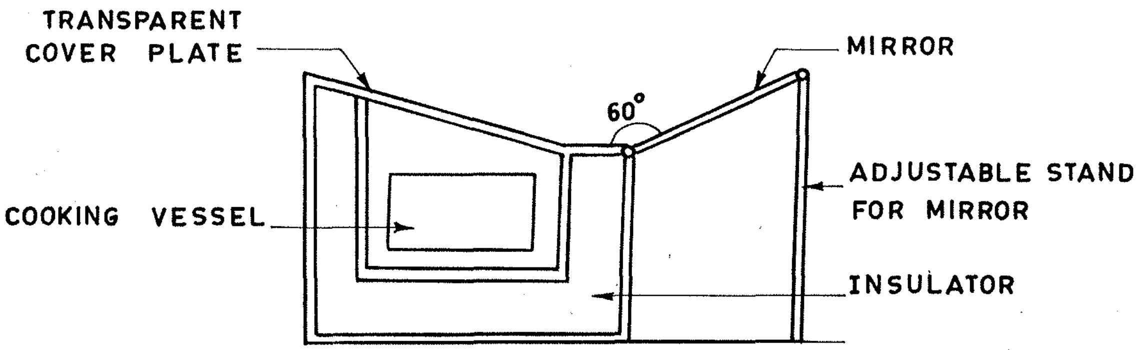
i. Box type cooker

The box type cooker is also known as 'hot box type solar cooker' (Brink worth, 1972; and Ramaraju, 1978), 'Stove type solar cooker' (Ghosh, 1977), 'flat top solar cooker' (Vijayaraghavan, 1984) and 'Flat plate type of solar cooker' (Parikh and Parikh, 1984).

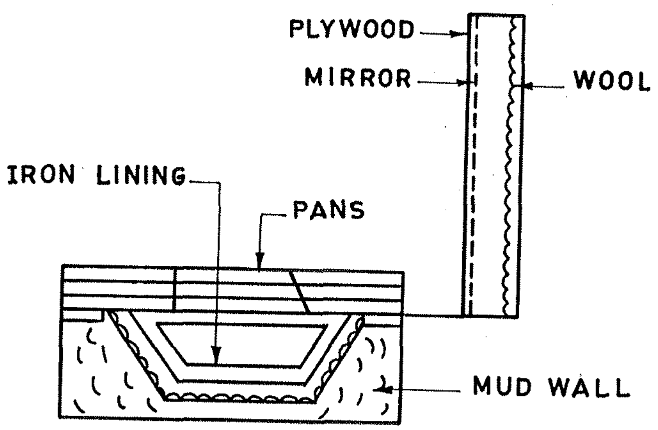
The box type cooker (Figure 10a) is one in which solar energy is trapped in a shallow box. It consists of a 10 to 11 cm. deep metal tray with sides, 45 to 50 cm. in length and breadth. This tray is covered, with two glass sheets at the top and is insulated from all other sides. The frame carrying glass cover acts as a lid. The food is cooked in shallow blackened containers which are placed in the shallow box. On good sunny days, it takes 2-3 hours to cook rice and dhal. Hence this cooker can be used to cook, day time meals on sunny days. The reflector is provided in such a way that it faces sun and directs solar



(a) FLAT BOX TYPE SOLAR COOKER



(b) HOT BOX TYPE SOLAR COOKER



(c) STOVE TYPE SOLAR COOKER

FIGURE 10 DIFFERENT BOX TYPE SOLAR COOKERS rays into the cooking box in order to increase the solar radiation. This box type cooker improves cooking efficiency over the simple box and can cook two meals a day on bright sunny days (Myles, 1981; Mannan, 1981; and Vaithilingam, 1984).

In a 'Hot box type solar cooker (Figure 10b) a reflector, making an angle of 60°C with the glass plate directs the solar radiation on the glass plate. It requires about one hour solar explosure for the chamber to attain an equilibrium temperature.

The stove type solar cooker (Figure 10c) is made by using wood and glass panes. Temperatures upto 120°C have been obtained in its insulated cooking space enclosed by two horizontal glass panes and a mirror reflected.

Low cost solar cookers designed by Gupta and Vasudevan (1983) with locally available materials are also available for food preparation. Temperatures upto 105°C to 115°C have been obtained in these box type solar cookers.

The box cooker with a single reflector has many desirable features (Mannan and Cheema, 1982):-

1. Loading and unloading of food from the top thus making all the cooking space easily available.

2. Shallow cooking box, thus reducing heat loss area.

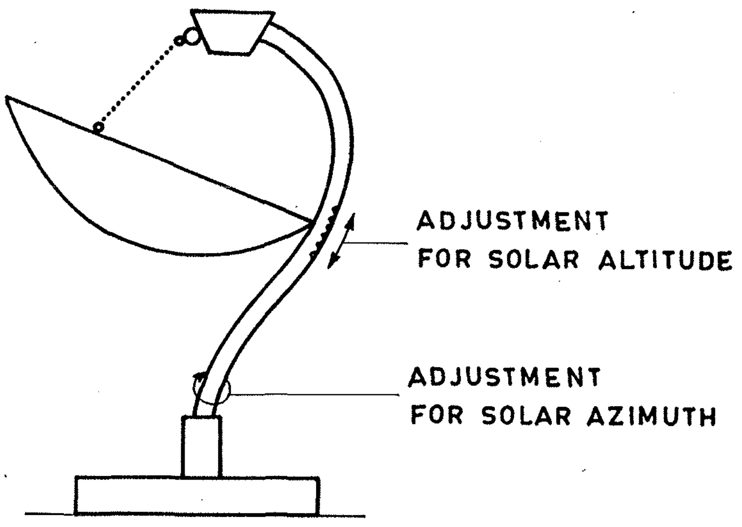
3. Always horizontal position of cook box thus eliminating the chances of spoilage of food during loading and unloading.

4. Simple design which is also easy for transportation and storage.

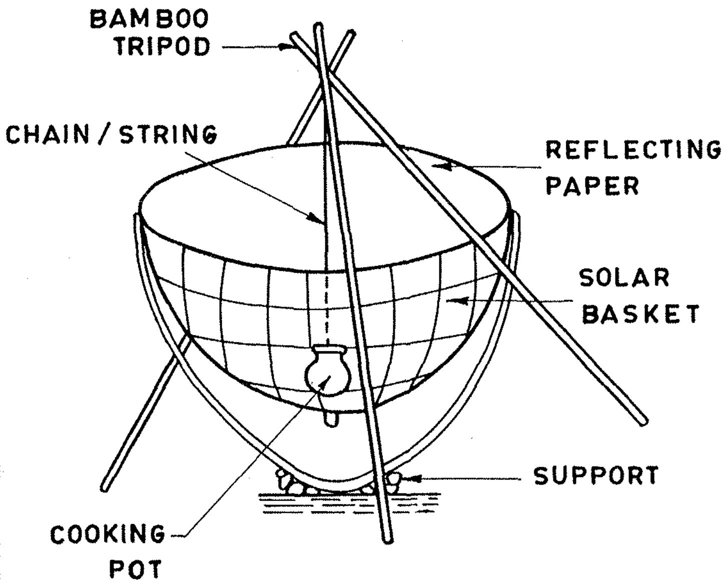
ii. Parabola Cookers.

Parabola cookers are also known as 'Parabola dish type cooker', (Mannan, 1981; and Myles, 1981), 'Solar basket' (Brink worth, 1972), 'Arthur's Model of a solar cooker, Ramaraju (1978), Focussing type cooker (TNAU, 1984) and Umbroiler i.e., Foldable umbrella type solar cooker' (Halchy, 1963 and Ramaraju, 1978; and Murthy, 1982).

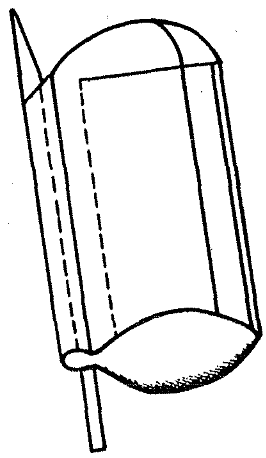
In dish type cooker (Figure 11a) solar energy is concentrated by using parabola dish reflecting surface. The reflecting surface is made either by using polished aluminium segments of appropriate shape or by pasting shining plastic film (Nylon) on suitably shaped substrate material or by some other suitable method. The reflector is mounted in such a way that it can be adjusted easily towards the sun every 10-15 minutes. The vessel containing the food



(a) PARABOLA DISH TYPE
SOLAR COOKER



(b) SOLAR BASKET



(c) GEOFF ARTHUR'S MODEL
OF A SOLAR COOKER

PARABOLA SOLAR COOKERS

FIGURE 11

to be cooked is placed at the focal spot of the reflector. High temperature is attained in this type of cooker and therefore almost everytype of conventional cooking can be done using this. It becomes unnecessary to stir and examine the food to be cooked quite frequently. The quantity of heat delivered to the cooking pot is proportionate to the diameter of the reflector (Myles, 1981; and Mannan, 1981).

The solar basket (Figure 11b) is the parabolic solar cooker which consists of a big deep basket covered with aluminium foil and mounted on three poles. Ravindra (1981) mentions that sun basket is an answer to the poor man's energy crisis. He further adds that solar basket is made out of locally available resources, saves the time spent in collecting fuel, provides safe, uniform heating and hygienic cooking with no hazards of smoke and fire.

Geoff Arthur's model of a solar cooker (Figure 11c) is a topless box of two and a half metres square. A parabolic curved sheet of metal is fixed inside the box. Eight tiny mirrors of the size of button are fixed on the curved sheet to focuss the sun's rays to the centre of the box where a metal tray holds a food to be cooked. The metal tray is placed on gimbals so that at any position the tray is kept horizontal.

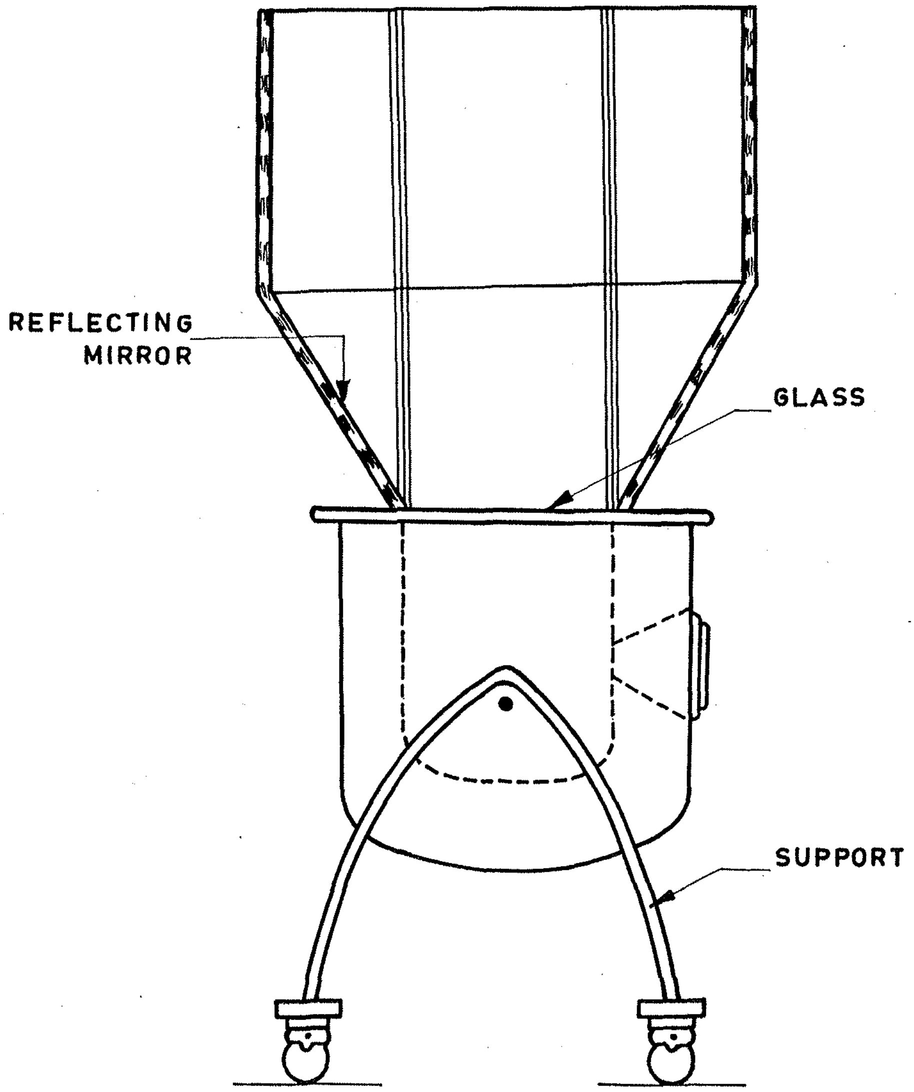
The foldable umbrella type solar cooker will be useful for a picnic party. Easily packed in a box for transporting, it can be set up in a minute and in about 25 mts in bright sunlight one can cook a meal (Halacy, 1963; Ramaraju, 1978; and Murthy, 1982).

The focussing type cooker may have mirror or metalysed polyester reflector.

iii. Solar oven

The National Physical Laboratory, New Delhi developed an oven type cooker in 1950. This type utilises plain glass sheets to focuss the reflected solar radiation inside a closed metal box. The temperature in the blackened box can be raised to a temperature of about 250°C on a clean sunny day. This cooker is suitable for cooking rice, dhal vegetables etc., for making cakes and biscuits (Ratnam, 1974; and Rajadhyaksha, 1980).

It is also known as conical reflector type solar cooker (Figure 12). This system consists of eight silvered sheets of glass. Cooking vessel is placed in a glass chamber and painted black at the bottom surface. Hot air surrounding the cooking vessel accelerates cooking. This device can attain a temperature of the order of 200°C (Ramaraju, 1978).



CONICAL REFLECTOR TYPE SOLAR COOKER

FIGURE 12

As mentioned by Mannan (1981), the solar oven uses a number of reflecting surfaces arranged in a conical fashion so that the solar energy input in the cooking zone is 2-3 times more compared to simple box design. Hence the cooking time is considerably reduced compared to that of box type cooker. This type of cooker needs to be adjusted towards the sun after every half an hour. Maximum temperatures of the order of 150°-200°C have been measured in the cooking zone during noon time.

A new solar oven with a looking glass reflector designed by CAZRI (Central Arid Zone Research Institute, 1977) is also available for food preparation. The maximum temperature reached is 350°C in summer and 250°C in winter. All types of foods can be cooked with this solar oven. Its performance is not affected by wind. It does not require frequent adjustments towards the sun.

Metcalf and Logvin (1981) point out that solar box cooker (SBC) is far superior to the solar cooking devices previously developed such as Hot Dog Cooker Parabolic Concentrator and Slant Faced Oven. According to these investigators, these devices could hold only small amounts of food, were poorly insulated and needed constant refocussing. Moreover they consider solar cooking with a box cooker is easier than conventional cooking because it requires less total time and effort.

b. Solar Driers

The oldest traditional application of solar energy is making use of the sun's heat for drying paddy, grain, corn, fish, chillies, tea, coconuts and other products. (Jena, 1981). The customery technique is to spread the food items on the ground and expose them to solar radiation. The products to be dried are turned up regularly until they are sufficiently dry to be stored for future consumption (Palaniappan, 1984).

Solar drying is one of the most simple and inexpensive means of low grade utilisation of solar energy. (Kaushik et. al.,1983). Solar drying in enclosure is to control the process and enhance product quality may result in improved utilisation of food stuffs (Kaskari, 1975).

The solar drier is essentially a hot box insulated at the base and covered with a sloping transparent glass roof absorbing directly solar heat. Radiation driers have a common space for collecting solar energy and for drying the product. Perforations are provided at the bottom and top of the space to allow for ventilation of evaporated moisture. The product is spread thinly in trays and exposed to radiation from the sun. For drying vegetables three models have been developed at TNAU, Coimbatore. They are

a. Flat plate solar drier.

b. Roof drier (similar to green house).

c. Cabinet drier.

The advantages of solar dryers are:-
A more evenly dried product of superior quality results, the noxious effects caused by dust or dirt, insect infestation etc., are overcome, the dangers of incomplete drying caused by sudden rainfall and high humidity are reduced and the time taken to dry agricultural produce is less. The limited space available in large cities may be effectively used for drying utilising small cabinet dryers (Harigopal and Jonapi, 1980).

c. <u>Solar water heaters</u>

The best known application of solar energy is for hot water heating. Improved technology lower manufacturing costs and strong marketing efforts enhanced by public policy may lead to substantial entry of solar hot water system into markets in areas where sunshine is strong during much of the year (Wilson, 1977; Garg, 1982; Salaiya and Singh, 1982; Diwan, 1983).

Isreal is a pioneer country in the utilisation of solar energy for heating water. Australia, Japan and

Florida have popularised the use of solar heaters for house-holds (Masters, 1976). Today, the technology developed in India on solar water heaters has reached a stage where it can be commercially exploited (Jain, 1980). Solar energy provides an untapped source for heating water for domestic as well as for industrial uses with advantages as for industrial uses with advantages as simplicity in construction and insignificant maintenance cost.

Solar water heaters are broadly classified into three types (Garg, 1982).

1. Box or pillow type in which the collector and the storage are combined into one unit.
2. Domestic type in which the tank is placed above the absorber for maintaining the pressure head necessary for natural circulation of water.
3. Large size units in which the storage tank can be placed at convenient location, circulation being accomplished with a booster pump.

Flat plate collectors made up of aluminium, copper and mild steel are generally used for heating water. The basic design of a water heater includes an arrangement for absorbing the sun's radiation known as heat collector or absorber, and a well insulated storage space for water. Water flows through blackened tubes connected to the flat plate and carries heat to the storage tank. If the tank is placed slightly higher than the collectors the water will circulate naturally without pumps due to the water density differences of hot and cold water (Chandra, 1978).

d. Solar still

Potable water supply schemes will take very long time and are uneconomical at present as Villages are scattered and thinly populated. There are many villages in the arid zone of India where the underground water is brackish, and unfit for drinking or cooking. A simple solution to this problem is a solar still as its operational cost and care under Indian conditions are very less (Mathur and Chandra, 1979; Tarnekar and Zadgaonkar, 1979; Diwan and Maini, 1981).

Fresh water is essential in households for drinking particularly in places where there is scarcity. The brine water to be distilled is kept in black bottomed stills covered with artificial enclosure of glass or plastic. Incident solar radiation passes through the glass cover and these are absorbed in the black bottom of the still covered with airtight enclosure of glass or plastic. The evaporated water gets condensed on the inner side of the glass sheet and trickles down through a channel provided at the lower edge of the cover to a container.

Distillation of water using solar energy offers promise for future. On a day with clear sunny climate the available production from such stills can reach 3-4 litres of fresh water per day per 4 square metre of radiation area.

The performance of the solar still depends on, a number of design parameters such as materials of construction, thermo physical properties of materials, base insulation, water depth, absorptance and transmittance properties of the glass and basin, glass angle and orientation, climatic parameters such as solar insolation ambient air temperature, wind speed, atmospheric humidity and sky conditions, and various other operational parameters.

The advantages in using solar distillation plant are stated by Ramaraju (1978) as follows:

1. Solar energy is abundant and freely available during the day time.

2. There is no transport problem involved in this field.
3. Solar energy devices do not pollute the atmosphere.
4. The maintenance and running cost of these devices are extremely cheap.
5. Solar energy can be used for making distilled water from sea water or waste water or hard water.
6. It is possible to design any size of stills to satisfy, laboratory, individual and other requirements.
7. The solar still can operate for longer periods without any maintenance.
8. Solar still will be useful to remote and arid areas where no distilled water is available.

3. <u>Constraints in Using Solar Energy</u>

The energy of the sun has to be converted to heat, work or electricity before it could be effectively utilised. Numerous constraints exist at various phases of tapping the solar energy. They must be overcome for wider and fuller use of solar energy. The intermittent nature of sun's radiation poses problems in the efficient utilisation of energy. Nair (1984) indicates that darkness and bad weather cause constant interruptions in the reception of the sun's energy. Suryanarayana (1978) and Fenyves (1983) point out that the source of solar energy reaching the earth is reduced in intensity in the atmosphere by clouds, dust and fog.

A knowledge of solar data such as the measurement of solar radiation, the intensity, total incident energy, transmission factor, clear or cloudy day variation and seasonal changes is imperative for the best use of solar energy (Ramachandran, 1976).

The use of the sun is unpredictable to the consumer, since radiation of the sun reaching any given spot is dependent on the time of the day, season of the year, latitude, cloud cover and aerial pollution (Wascheck and Carmen, 1978). Solar energy in the form of heat is available only nine hours in a day reaching peak insolation (about 0.9 kW/m^2) around noon indicating that solar power plants remain shut off during the rest of the hours (Sing, 1980).

Broda (1980) mentions that solar energy has the following limitations:

1. Unequal distribution over the globe.
2. Intermittency.
3. Dilution.
4. Loss of directionality.

With reference to the use of solar cookers in households, Behrman (1978) and Mathews (1979) indicate that custom is a barrier against the Indian's using solar energy appliances, since cooking is traditionally confined to the interior of the house and not to the open yard.

Some of the cooking methods such as seasoning and frying which are essential in Indian cooking cannot be done in solar cookers (Vaithilingam, 1984). Ramaraju (1978) and Mathur (1983) mention the following practical difficulties in the use of solar cookers on permanent basis:-

1. Social habits.
2. Inadequate promotional efforts.
3. High and prohibitive cost of the solar energy devices.
4. Vagaries of sunshine, shades, cloud, rain etc.
5. Sun tracking difficulties - (sun itself is oscillating).
6. Not suitable for all types of cooking.

Availability of solar energy to suit the cooking hours of the people, long duration of cooking, use of delicate parts like glass in the cooker were the problems observed by Vasudevan and Santosh (1983) and Vidyarthi (1983) in solar cooking. Bhusan (1977) states that the main drawback of the 'Sun-basket' is that it can be easily damaged if handled roughly. If it is left over in the rain, it will loose its shape and become useless. While cooking one has to be careful to see that nothing is split over the basket, because any kind of overflow from the cooking pot will reduce the reflectivity of the inner surface. The person needs to wear sun glasses to shade the eyes against the glare of the unfocussed sun rays.

The main reasons obstructing the popularisation of solar cookers are (a) social habits, (b) technical draw backs and (c) inadequate promotional efforts. Furthermore solar cooking involves alteration in the household routine, since the housewife must prepare the evening meal during day light well before the traditional time. This poses the additional problem of keeping the food hot (ESCAP, 1980', and Rao, 1985).

While developing technology for utilisation of solar energy, a deep consideration of sociological and economic aspects is necessary. Durability, reliability, ease of installation and use, achieving higher efficiencies of performance and cost reduction are some of the major problems faced by the scientists and engineers for developing devices for utilisation of solar energy (Pichai, 1984).

In any programme for the introduction and use of solar cookers, the technology of cooking, local practices, economic factors and the availability of local skills are the essential parameters for success.

III. PROJECT PROFILE

The methodology followed for this study consisted of the following steps:

A. Studying the Fuel Management Practices in the Selected Villages,

B. Selecting the Appropriate Fuel Technologies to be introduced,

C. Creating an Awareness on Improved Fuel Technologies among the Rural Families Through Motivation and Education

and D. Evaluating the Impact of the Adoption of these Improved Fuel Management Practices.

A. Studying the Fuel Management Practices in the Selected Villages

The steps involved in this aspect were

1. Selecting the villages and households,
2. Selecting the method of study

and 3. Collecting and Analysing the data.

1. Selecting the Villages and Households

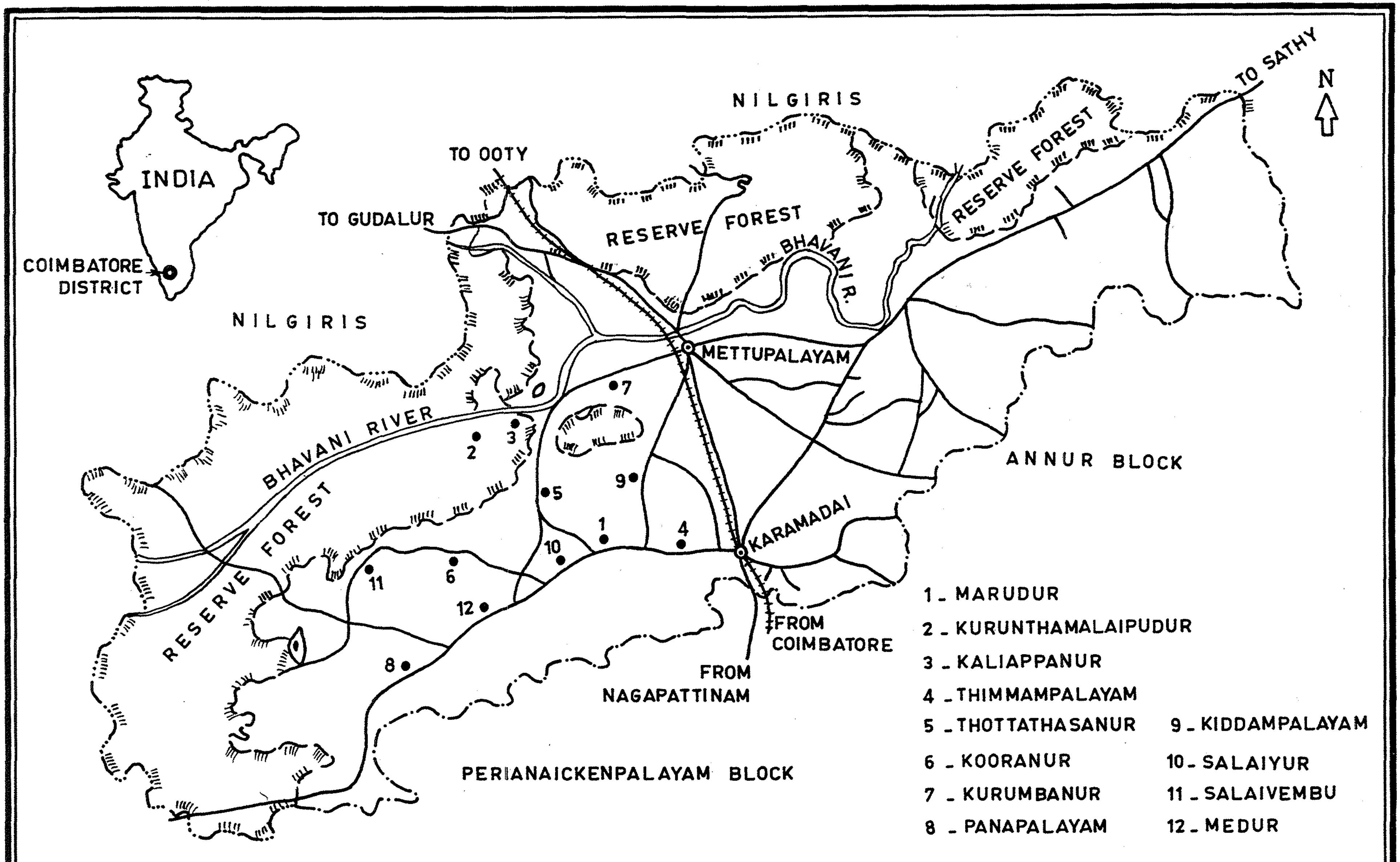
The villages in Karamadai Panchayat Union of Coimbatore District were selected for the project since Sri Avinashilingam Home Science College had chosen this area for integrated rural development in commemmoration of their Silver Jubilee Celebrations. A total of 914 households spread in the following 12 villages in this area were selected for this aspect of the study. The households were selected by purposive sampling method which is described by Muthayya et. al. (1976) and Vilkinson and Bhadarkar (1982) as selecting the items from the Universe in such a way that they are typical representation of the whole. Figure 13 shows the locale of the selected villages.

The Villages selected for the study are given below:

1. Marudur
2. Kurunthamalaipudur
3. Kaliappanur
4. Thimmampalayam
5. Thottathasanur
6. Kooranur
7. Kurumbanur
8. Panapalayam
9. Kiddampalayam
10. Salaiyur
11. Salaivembu
12. Medur.

2. Selection of Method for the Survey

The 'Interview Method' was selected for gathering



LOCALE OF THE VILLAGES SELECTED FOR THE STUDY
(KARAMADAI PANCHAYAT UNION, COIMBATORE DISTRICT)

FIGURE 13

SCALE: 1cm = 3 km

information owing to its convenience, comprehensiveness and possibility of obtaining genuine information. As Rangaswamy (1976) and Gupta (1976) affirm 'direct personal interview method provides positive response and accurate information'.

An interview schedule was prepared to collect details on the family background, type of fuel used, fuel management practices adopted and their awareness on improved fuel technologies developed for household purposes. Appendix II shows the schedule used for the survey.

3. Collecting and Analysing the Data

Good rapport was established with the families and interviews conducted, at a time convenient for them to gather the data. While conducting the survey, the households interested in using improved fuel technologies such as smokeless chulah, biogas and solar cookers were also identified.

The data collected was consolidated and analysed. The findings of the survey are presented as follows;

1. General Details of the Surveyed Families

The caste, the type of family, age-wise distribution of the people in the families, occupational status of the head of the family, literacy level of the head of the family and home makers and income range of the surveyed families are presented.

a. Caste

Table VI presents the caste structure in the villages under study.

TABLE VI

CASTES EXISTING IN THE VILLAGES

S.No.	Caste pattern	N:914	Percentage
1	Backward Class	740	81.0
2	Forward Class	77	8.4
3	Scheduled Caste	94	10.3
4	Scheduled Tribe	3	0.3

The sample surveyed had a dominance of Backward class (81 per cent). Ten per cent of the sample were from scheduled caste. Scheduled Tribe occupied only negligible percentage of the sample.

b. Family Type.

Table VII depicts the type of families identified in the villages surveyed.

TABLE VII

TYPES OF FAMILIES IN THE VILLAGES

S.No.	Type of family	N:914	Percentage
1	Nuclear	851	93
2	Joint	63	7

A large majority, 93 per cent of the sample were of nuclear type. These figures indicate the almost complete decline of the joint family system in the rural areas.

c. Age-wise Distribution of the Population

The distribution of the population according to age is depicted in Table VIII.

TABLE VIII

AGE-WISE DISTRIBUTION OF THE POPULATION

S.No.	Age in years	Total number of population	
		N:3991	Percentage
1	Pre school (0-5)	391	10
2	School going (6-12)	402	10
3	Adolescent (13-19)	847	21
4	Adulthood (21-60)	1935	49
5	Old age (above 60)	416	10

The preschool, school going and old age each occupied 10 per cent of the population. The adolescent constituted 21 per cent and the adults 49 per cent. This indicates that the village had good work force potential constituting a high percentage of adolescents and adults. This statistic was found to be nearly equal to the national average (52 per cent of the population being in this age group).

d. Educational Status of the Heads of Families

Table IX indicates the educational status of the heads of families.

TABLE IX

EDUCATIONAL STATUS OF THE HEADS OF FAMILIES

S.No.	Educational Status	N:914	Percentage
1	Illiterate	702	77
2	Primary school	84	9
3	Middle school	60	7
4	Higher secondary level	55	6
5	College level	13	1

More than 70 per cent of the heads of the families were illiterate. The National Adult Education Programme, which has been launched in a big measure must help to solve the problem of adult illiteracy in the rural areas.

The educational status of the home makers is shown in Table X.

TABLE X

EDUCATIONAL STATUS OF THE HOME MAKERS

S.No.	Educational status	N:914	Percentage
1	Illiterate	762	83
2	Primary school	65	7
3	Middle school	52	6
4	Higher secondary level	27	3
5	College level	8	1

The position of the home makers in the sample with regard to education was also poor, with more than 80 per cent being illiterate. The National Adult Education Programme should be strengthened in order to help women.

e. <u>Occupational Status</u>

The occupational pattern of the heads of the families is shown in Table XI.

TABLE XI

OCCUPATIONAL PATTERN OF THE HEADS OF FAMILIES

S.No.	Occupational pattern	N:914	Percentage
1	Agricultural labourers	458	50
2	Agriculture (land owners)	356	39
3	Self employment*	43	5
4	Employed in Industries	39	4
5	Business	18	2

* Self employment includes barber, tailor, dhoby and small petty shop owners.

All the heads of the families were gainfully employed with a majority working as agricultural labourers. Nearly half of the sample possessed land and worked as agriculturists cultivating their own land. Since most of the villages were situated in the interior of Karamadai, and they do not have close proximity with the industrial area, only a negligible percentage of families were employed in industries.

f. Income expenditure pattern

Table XII reveals the distribution of the households according to their annual income.

TABLE XII

DISTRIBUTION OF FAMILIES ACCORDING TO ANNUAL INCOME

S.No.	Annual income in Rs.*	N:914	Percentage
1	Less than 2500	152	17
2	2501-5000	573	62
3	5001-7500	152	17
4	7501 and above	37	4

* The classification was based on the Times of India, Directory of Year Book, 1979, p.19.

On an average 17 per cent of the sample is getting a fairly good income, Rs.5001-7500 annually.

2. Fuel Management Practices

This aspect is discussed under the following headings:

a. Fuels used and sources of availability,

b. Quantity of fuel used,

c. Expenditure on fuel,

d. Type of chulah and utensils used,

e. Fuel storage practices

and f. Problems related to fuel management.

a. Fuels Used and Sources of Availability

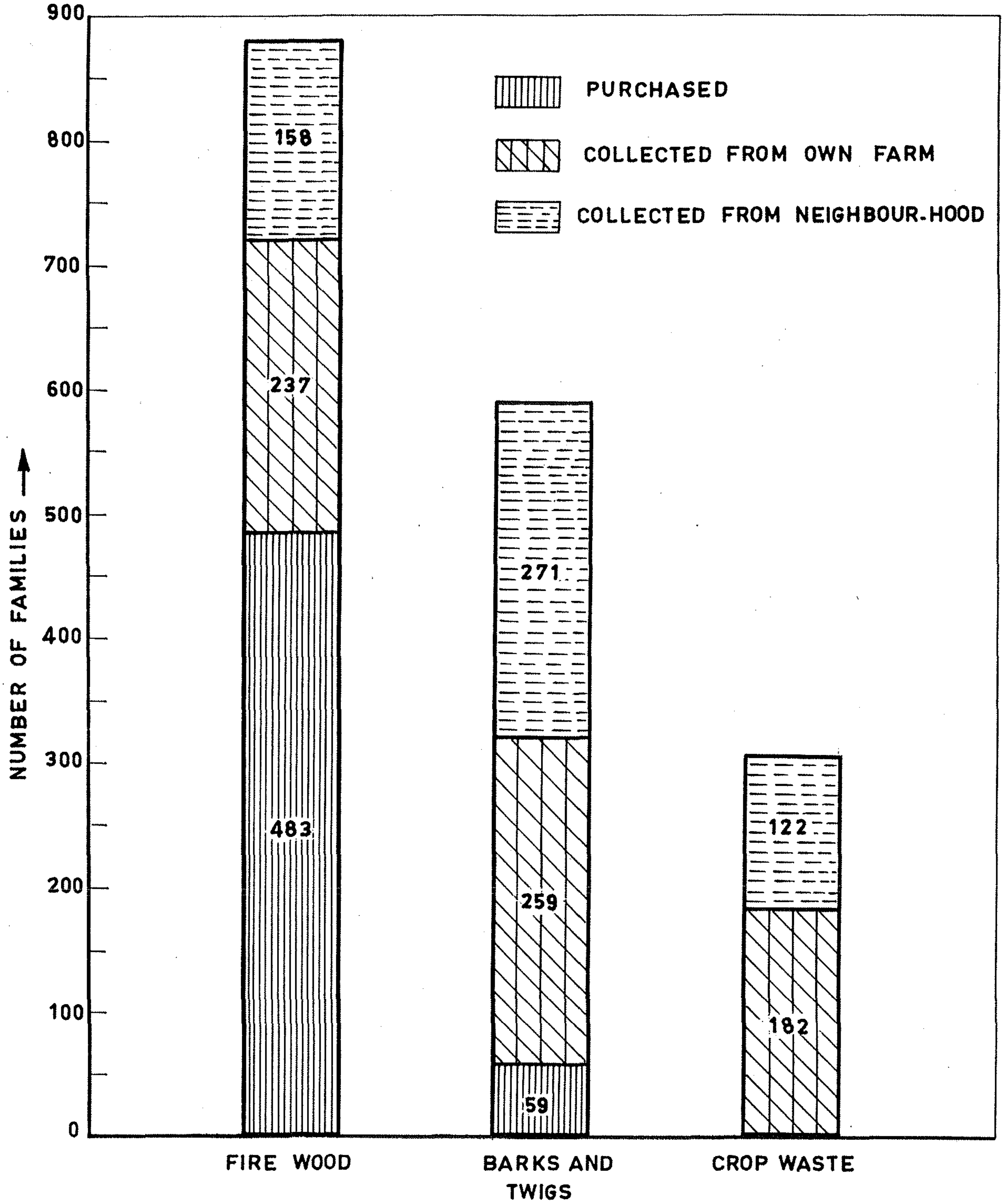
Table XIII and Figure 14 indicate the type of fuel used in the households and the places from where the families procured the fuels.

TABLE XIII

TYPES OF FUELS USED AND SOURCES OF AVAILABILITY

S.No.	Fuels and sources	Percentage of families
1.	Firewood (878)	
	Purchased	55
	Collected from own farm	27
	Collected from neighbour-hood	18
2.	Barks and Twigs (589)	
	Collected from own farm	44
	Collected from neighbour-hood	46
	Purchased	10
3.	Crop waste (304)	
	Collected from own farm	60
	Collected from neighbour-hood	40

Data in paranthesis indicate the number of families using the particular fuel. The percentage on sources was calculated based on these numbers.



TYPES OF FUELS USED AND SOURCES OF AVAILABILITY

FIGURE 14

Firewood, barks and twigs, wastes of crop such as cotton stalks and chilly plant were the fuels used in the households. More than half of the sample purchased firewood, while many households collected the fuel from their own farm or from the neighbour-hood. Easy availability, cost and convenience in use, were the reasons mentioned by the families for the use of the particular fuels. To collect these fuels 75 per cent of the families had to walk a minimum of three kilometres daily. Some of the members collected fuels on their way back home from their fields, which did not involve an additional trip for the purpose. The data collected reveal that in more than 70 per cent of the families women and children were involved in collecting the fuels in addition to doing other domestic chores. While 40 per cent of the families spent one hour a day for collection of fuels the remaining families spent more than two hours a day. Table XIV and Figure 15 show the typical work distribution pattern of rural women in the selected villages.

TABLE XIV

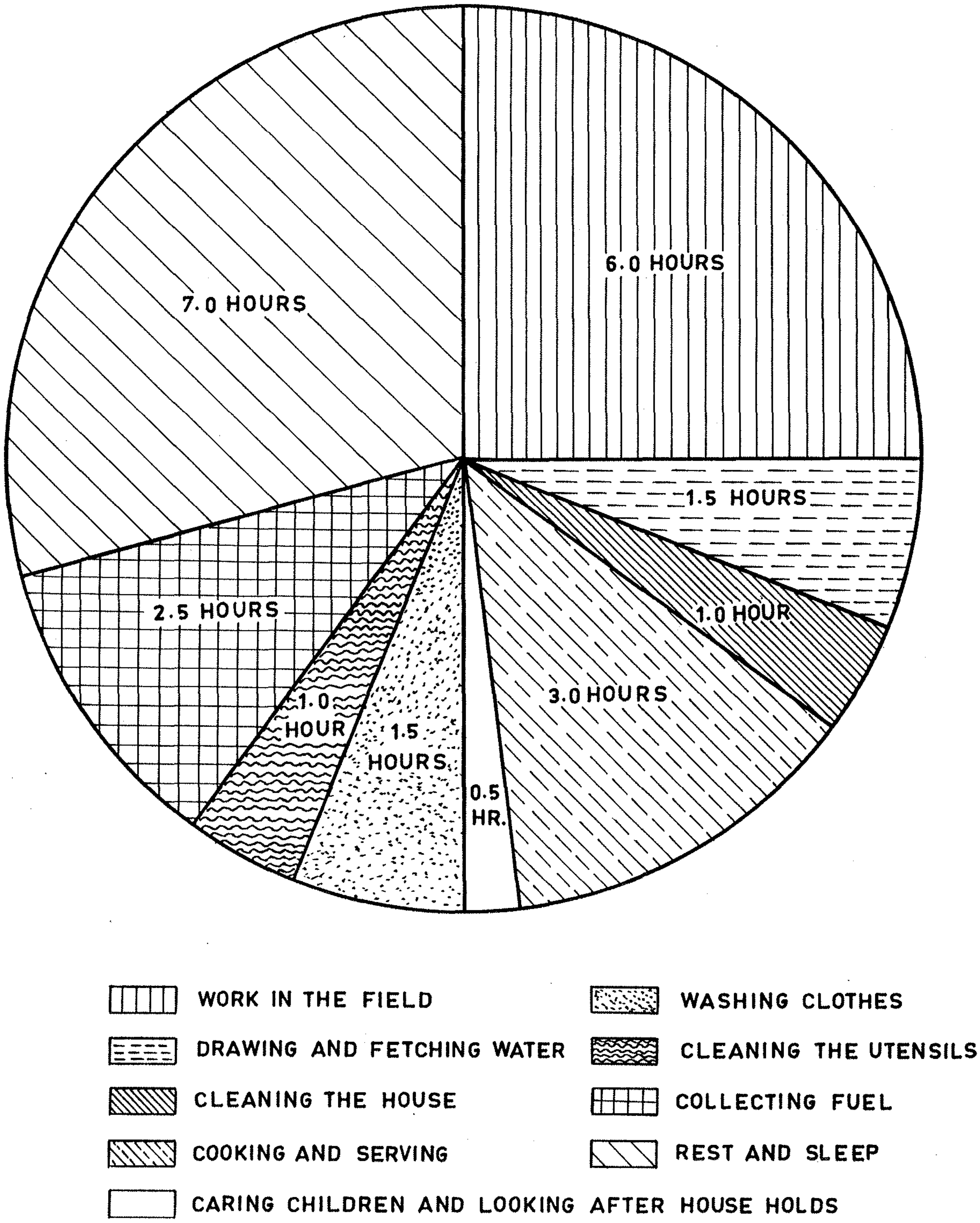
WORK TIME DISTRIBUTION OF RURAL WOMEN IN HOURS PER DAY

S.No.	Work pattern	Time in hrs/day	Percentage of time spent*
1	Work in the field	6.0	25
2	Drawing and fetching water	1.5	6
3	Cleaning the house	1.0	4
4	Cooking and Serving	3.0	13
5	Caring for children and looking after households	0.5	2
6	Washing clothes	1.5	6
7	Cleaning the utensils	1.0	4
8	Collecting fuel	2.5	11

* Rest and sleep occupies 29 per cent of the time.

An analysis of the life pattern of the rural women indicates that they provide 17 hours of productive labour in different chores. Fuel collection and cooking appear to be unavoidable chores in the rural family. Due to tradition these have been considered the jobs of women. In particular the women are greatly subjected to drudgery in the following chores:

1. Collecting fuel for a major part of the day.
2. Cooking in smokeful environment using traditional chulahs.



WORK TIME DISTRIBUTION OF RURAL WOMEN IN HOURS PER DAY

FIGURE 15

3. Walking long distances to fetch water.
4. Agricultural operations.

b. Quantity of Fuel Used

Eighty two per cent of the families surveyed reported that they use 2 to 3 kg. of firewood per day. The quantity of fuel used varied with the purpose for which the fuel was used, the number of meals prepared, items on the menu, the quantity of food cooked and the type of chulah used.

c. Expenditure on Fuel

An analysis of the expenditure pattern showed, that the expenditure on food was the major item, being 85-90 per cent. A large majority of the sample spent upto 10 per cent of their meagre income on fuel. The other items of expenditure such as clothing, education, health, and recreation had been given only minor consideration.

d. Chulahs Used

All the homemakers used only ordinary chulahs. Sixty nine per cent used two pot seated ordinary chulah, while 31 per cent used one pot seated chulah. Eighty nine per cent placed the chulahs at floor level, the remaining families had the chulahs at higher working levels. The chulahs are designed by the local potters without any scientific background.

The mouth of the chulahs are big and consume much fuel, making the chulahs inefficient.

Utensils Used for Cooking

Table XV gives the details of the cooking utensils.

TABLE XV

UTENSILS USED FOR COOKING

S. No.	Utensils used	Percentage of families N:914					
		Boiling	Steaming	Frying	Roasting	Stewing	Heating of water
1	Mud	48	12	21	19	27	46
2	Aluminium	45	83	58	46	64	49
3	Brass	5	5	--	--	--	--
4	Stainless Steel	2	--	--	--	--	--
5	Iron	--	--	21	35	--	--

Aluminium was found to be commonly used for boiling, steaming, frying, roasting, stewing and heating water, slowly replacing the traditional mud pots used in the rural households. Brass was used to prepare coffee and to boil milk. Iron was used for frying and roasting. The use of stainless steel was rather uncommon.

e. Fuel Storage Practices

The fuel collected was reported to be stored by the majority (80 per cent) on the floor in the backyard, front yard and in the available open space. In rainy seasons the fuel was stored on 'paran', a bamboo or wooden construction either attached to the walls or suspended by coir ropes from the roof.

f. Problems Related to Fuel Management

The problems related to fuel management as revealed from the survey are enumerated as follows (Figure 16):

i. Problems associated with collection of fuel

1. Walking 2 to 3 km. every day.
2. Spending 2 hours daily for this task.
3. Fear of land lord and forest authorities since the fuel is collected in an unauthorised manner.
4. Dangers of poisonous snakes and insects.
5. Difficulties in cutting and carrying the load on the head.

ii. Problems Associated with Storage of Fuels

1. Lack of space to store the fuel.
2. Accumulation of dirt.
3. Menace of pests and insects.

iii. Problems Related to the Use of Firewood and Other Agricultural Wastes as Fuel

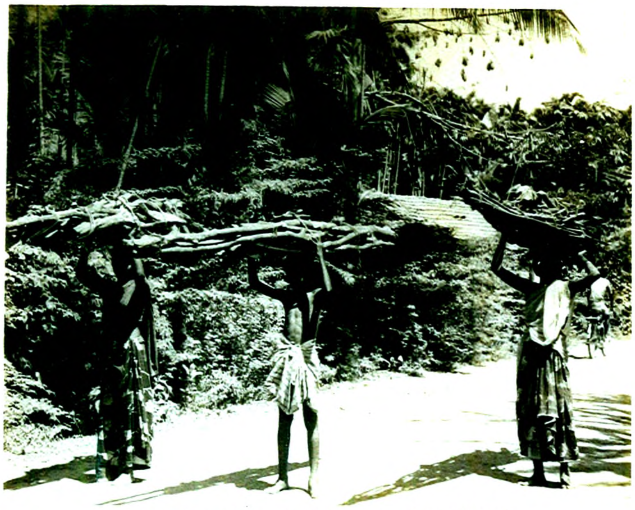
1. Difficulty in lighting the fire.
2. Inefficient burning.
3. Frequent feeding necessitating continuous attention.
4. Wastage of fuel.
5. High cost of the fuel.

iv. Problems Associated with the Use of Ordinary Chulah

The smoke which comes from the chulah causes several problem such as,

1. Eye strain.
2. Deposits soot on the utensils.
3. Dirties the clothes.
4. Difficult to maintain.
5. Blackens the kitchen.
6. Consumes more time to cook.
7. Takes more time to clean the utensils.
8. Drives the children away from kitchen.
9. Spoils the atmosphere of the house.
10. Weakens the efficiency of the homemaker.

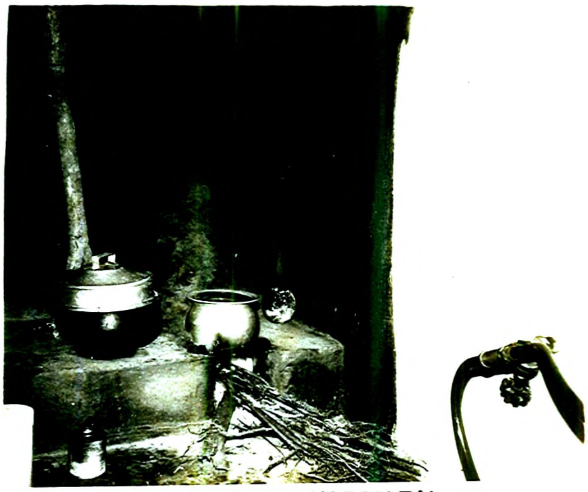
The respondents were highly conscious of the many problems in their fuel management practices. Ninety five per cent of the homemakers mentioned the need to change the



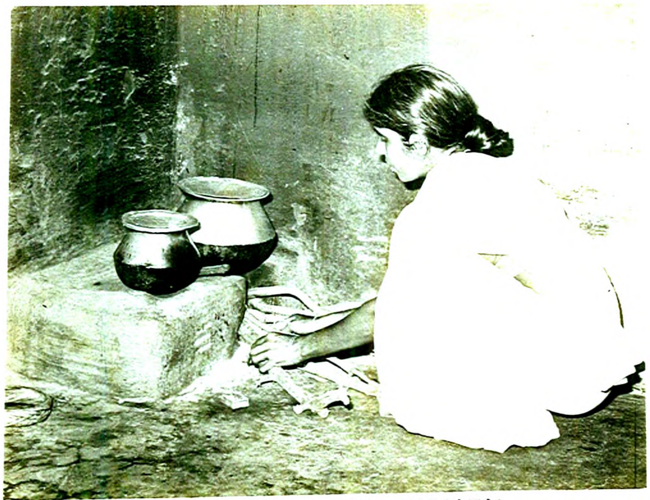
WALKING LONG DISTANCE

LACK OF STORAGE

INEFFICIENT DEVICE



SMOKY KITCHEN



DRUDGERY FOR WOMEN

SOOT DEPOSITED UTENSILS

PROBLEMS RELATED TO EXISTING FUEL MANAGEMENT PRACTICES

FIGURE 16

traditional chulah to overcome the problems associated with it.

Use of Solar Devices

An attempt was made to find the awareness of the families about the use of solar devices for cooking. It was found that only a negligible percentage responded. On enquiry about their willingness to use such devices, the response was rather poor; only five per cent of the homemakers showed some interest to experiment with solar devices.

Awareness About Biogas

The survey indicated that among the 914 families surveyed, 35 per cent of the sample owned 3 to 4 cows or buffaloes for their agricultural operations. The awareness on generating biogas from cattledung and using it as a fuel was evident only among five per cent of the respondents. But even those families had not set up biogas units in their household. The reasons were,not knowing the procedure for applying for the loan and the techniques involved in the construction and the method of using biogas. However they had expressed their desire to gain knowledge on 'Biogas technology'.

The findings of the survey brought out the felt needs of the rural homemakers with regard to fuel management. They were:

Need for

- Knowledge on improved fuel management practices
- Knowledge about the method to improve the efficiency of the chulah.
- Enhancing the appearance of the kitchen and removal of the drudgery of smoke,
- Experimenting with the use of innovative fuel technology such as biogas and solar energy.
- Understanding the method of utilising cowdung in a more efficient way.
- Knowledge regarding the assistance given by the government for these programmes.

B. Selecting Appropriate Fuel Technologies to be Introduced

This aspect had the following steps:

1. Selecting the technologies

and 2. Selecting the specific device to be introduced.

1. Selecting the Technologies

The National Research and Development Corporation (NRDC), New Delhi, has worked out specific, flexible set of criteria for selecting appropriate technology. Any technology introduced in the rural areas should

- be capable of generating employment-utilising local human and material resources.
- be capable of replication and should blend harmoniously with existing eco system.

- need low capital investment and result in low cost production.
- be capable of upgrading and enhancing traditional skills and capabilities.
- minimise fatique and reduce drudgery.
- be innovative in character.

Based on the felt needs of the community as well as keeping in view, the criteria given by NRDC, the investigator identified three improved fuel saving techniques as appropriate to alleviate the drudgery due to faulty fuel practices. They are as follows:

- Removing the drudgery of smoke by introducing 'Improved chulah' known as smokeless chulah.
- Utilising the abundant cowdung available for producing biogas by setting up biogas plants.
- Developing an awareness among the rural families regarding renewable sources of energy such as solar energy for cooking.

2. Selecting the Specific Devices to be Introduced

Several designs of smokeless chulah, solar cookers and biogas plants are propagated in the country to suit different local conditions. Preliminary experiments were conducted by the investigator to select appropriate design for introduction in the selected rural households.

a. Smokeless Chulah

Several varied designs of smokeless chulah are available in the country. After conducting a number of experiments with all available models for fuel and time consumption a smokeless chulah was designed at Sri Avinashilingam Home Science College to suit local conditions giving careful considerations for the diameter of the pot seats, height of chimney, height of the chulah and size of the feeding mouth so as to maximise the thermal efficiency. The basic material for firebox and chimney was mud, easily available in any village. The design of the chulah was based on the existing model used by village women and was easy to operate. The thermal efficiency of the chulah designed was found out to be 25 per cent (Appendix III).

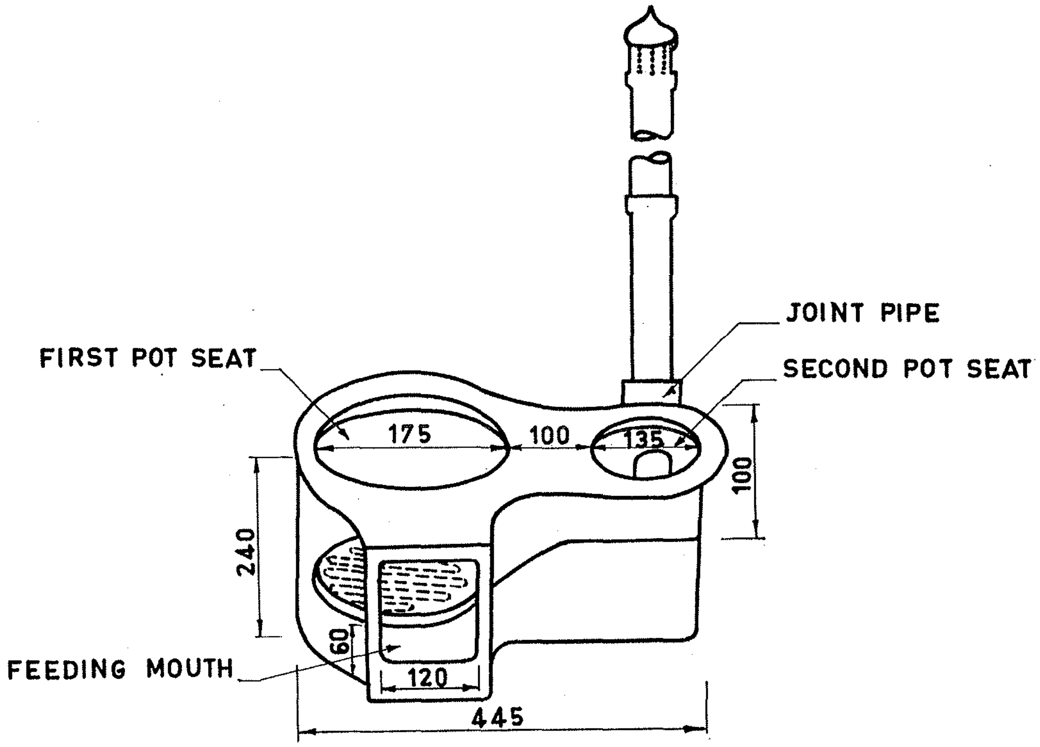
The physical features of the designed chulah were as follows:

Diameter of the pot seat I	175 mm.
Diameter of the pot seat II	135 mm.
Distance between the pot seats	100 mm.
Width of the feeding mouth	120 mm.
Height of the feeding mouth	120 mm.
Height of the chulah	240 mm.
Length of the chulah	445 mm.

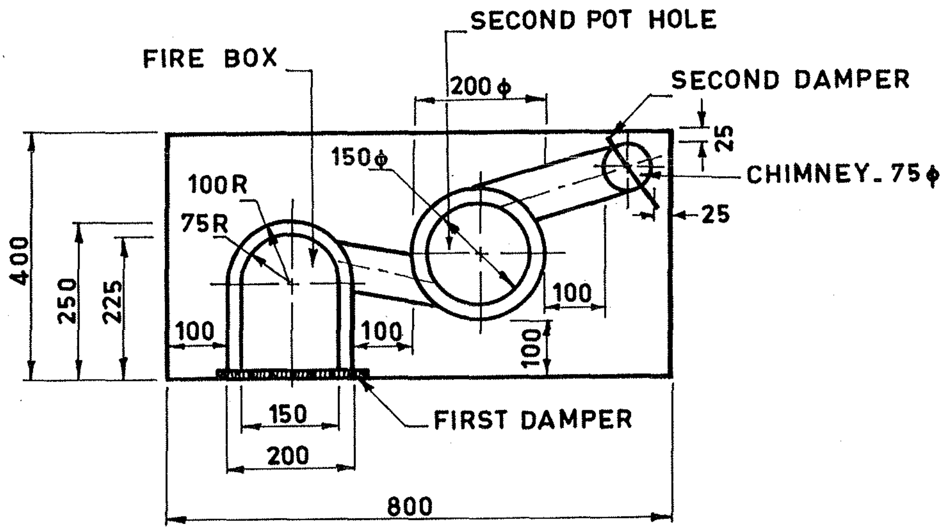
The pot seats were designed to facilitate the use of utensils of different sizes for two varied functions. While the first pot seat was meant for cooking rice, the second pot seat (smaller one) could be used for cooking dhal and vegetables. The size of the feeding mouth was designed to be smaller in order to minimise feeding with only the required amount of firewood.

The efficiency of the chulah designed was tested against the standard I.I.T. model ('Sahyog') which was being used by the various institutions associated with the All India Co-ordinated Project sponsored by Department of Science and Technology. Figures 17 and 18 show the dimensional sketches and pictures of the smokeless chulahs selected for the study.

'Cooking' rice was selected for the experiment to compare the chulahs in terms of time expended for the preparation and cleaning utensils and fuel consumption. In the beginning of each experiment the same quantity of fuel (1500 grams of firewood) was weighed for each chulah and fed into the particular chulah. After completing the cooking of rice, the quantum of firewood remaining from each of the chulahs was weighed again to note the fuel consumption in each case. The time consumed for cooking was recorded. While the first pot seat was used to 'cook rice', the second



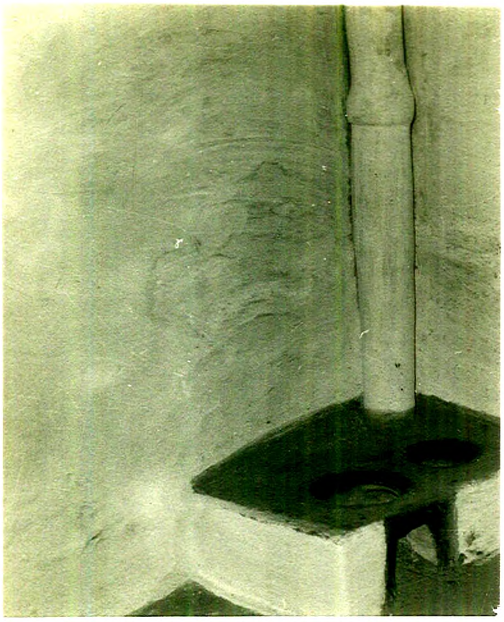
AVINASHILINGAM MODEL SMOKELESS CHULAH



SAHYOG CHULAH (I.I.T. MODEL)

FIGURE 17

ALL DIMENSIONS ARE IN mm



AVINASHILINGAM MODEL
SMOKELESS CHULAH

SAHYOG CHULAH
(I.I.T. MODEL)

SMOKELESS CHULAHS SELECTED FOR COMPARISON

FIGURE 18

pot seat was used simultaneously to heat water in a separate utensil of identical shape and size. The temperature of water kept in the second pot seat at the time of completion of cooking rice on the first pot seat, was also recorded. Table XVI presents the findings of the comparative study of the two selected models.

TABLE XVI

COMPARISON OF 'AVINASHILINGAM' MODEL WITH 'SAHYOG' (I.I.T. MODEL)

Factors of comparison	Trials	'Avinashilingam' model	'Sahyog' (I.I.T model)	Difference
Firewood consumption (in grams)	1	1000.0	1000.0	
	2	900.0	960.0	
	3	940.0	920.0	
mean value		946.0	960.0	14 gms.
Time consumption (in minutes)	1	44.0	50.0	
	2	45.0	52.0	
	3	44.0	50.0	
mean value		44.3	50.6	6.3 min.
Temperature (in centigrade)	1	62.0	56.0	
	2	63.0	57.0	
	3	62.0	56.5	
mean value		62.3	56.5	5.8°C

The findings indicated that 'Avinashilingam' model chulah consumed less fuel and time for cooking rice which is the major item being cooked in rural households.

b. Biogas Plant

The two popular designs adopted in Indian villages namely Khadi and Village Industries Commission design and the model developed by Planning Action and Research Institute, Lucknow, known as 'Janata' Model were compared.

The study conducted by Manivasuki (1985) in 100 households in Coimbatore District pointed out a changing trend in recent years in the adoption of models by the rural households; 82 per cent of the respondents owned 'Janata model' (drumless type) and only 18 per cent had constructed the conventional KVIC models.

Therefore a comparative study was undertaken on the two models. The following aspects were found through experiments in the campus and interviews with the owners of the plants (Table XVII).

TABLE XVII

COMPARISON BETWEEN KVIC MODEL AND JANATA BIOGAS PLANT

KVIC	JANATA
1. The construction of 3 cu.m. capacity gasplant costs Rs.3400 in the year 1981.	The construction of 3cu.m. capacity gasplant costs Rs.2264 in the year 1981.
2. The movable steel gas holder corrodes and needs continuous attention.	The design does not include a movable steel gas holder.
3. This requires high transportation charges to transport fabricated gas holder to the site.	No transportation charge is necessary since the whole plant is constructed at the site.
4. Life span of the gas holder is fixed for 10 years.	Life span of the unit is expected to be more than 10 years.
5. The gas plant occupies more space.	The gas plant occupies less space.
6. The gas production during winter season is less.	The gas production in winter season is comparatively more since the whole unit is an underground construction.
7. Locally available materials can be used for construction of digester only. The fabrication of gas holder requires workshop facilities.	Locally available materials can be used for the whole plant. Trained skilled masons are necessary for the construction of dome portion.

There are many favourable points in adopting Janata model biogas plant.

c. Solar Cookers

Among the various solar devices available, solar cookers were selected owing to their relatively lower cost in comparison with dryers or heaters and the greater necessity for cooking devices. The available three models of solar cookers were assessed for their efficiency by conducting cooking experiments and evaluating their physical features for acceptability by homemakers.

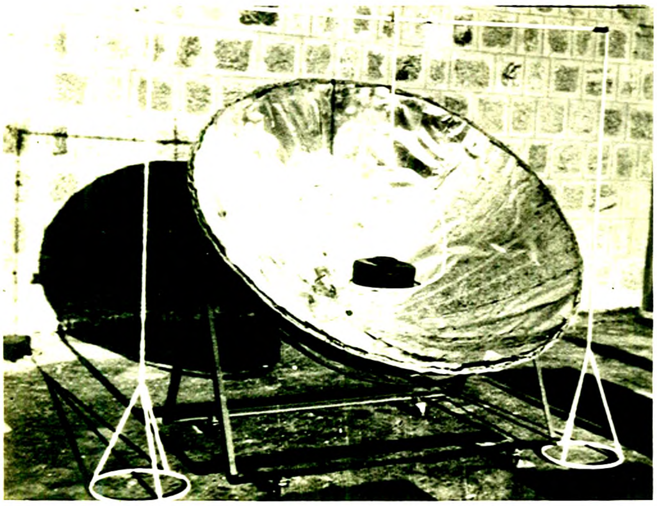
The three types of solar cookers selected were simple box type cooker, reflector oven and the solar basket (Figure 19).

Since cooking with solar energy is a slow process such foods which do not adversely get affected in their nutritive contents by long cooking were selected. Rice, dhal and vegetables were the items selected for cooking since a large majority in the rural areas include them in their daily diet.

An appropriate place with adequate direct sunlight during 8 A.M. to 5 P.M. was selected for placing the solar cookers. In order to maximise both the solar radiation and its focussing, the position of the solar cookers was adjusted to the corresponding changing altitudes of the sun. The time taken for cooking the items selected was recorded

BOX TYPE SOLAR COOKER

REFLECTOR OVEN



SOLAR BASKET

SOLAR COOKERS SELECTED FOR EXPERIMENT

FIGURE 19

(Appendix IV). Table XVIII gives the mean time to cook the selected items.

TABLE XVIII

MEAN TIME TAKEN TO COOK THE ITEMS IN THE SOLAR COOKERS

S. No.	Items	Quantity in gms.	Time taken in minutes		
			Box type	reflector oven	Solar basket
Cereals					
1.	Rice	80	55.0	61.6	45.0
Pulses					
2.	Greengram dhal	50	56.6	68.3	45.0
3.	Whole green gram dhal	50	71.6	95.0	53.3
4.	Redgram dhal	50	88.3	103.3	80.0
Vegetables					
1.	Potato	100	70.0	95.0	66.6
2.	Carrot	100	58.3	70.0	55.0
3.	Beans	100	41.6	65.0	36.6

The solar basket took the least time to cook the items. This may be due to the high reflection area available.

The ease in handling the three type of solar cookers was evaluated by ten home makers (Table XIX).

TABLE XIX

EVALUATION OF THE THREE TYPES OF SOLAR COOKERS

S. No.	Criteria	Percentage of Home makers stating		
		Box type	Reflector oven	Solar basket
1.	Comfortable height	60	60	70
2.	Manageable size	90	40	40
3.	Convenient shape	80	40	40
4.	Durability of materials used for construction	90	80	70
5.	Easy mobility	80	20	70
6.	Easy to clean	80	50	80
7.	Easy to maintain	80	50	60
8.	Easy to handle	90	40	90
9.	Easy to store	90	50	40
10.	Less attention at the time of cooking	90	50	40
	Mean value	83	48	60

Judged by the various criteria the box type solar cooker was found to be desirable to a greater extent for the homemakers. Therefore this type was selected for introduction in the rural households.

C. Creating an Awareness on Improved Fuel Technologies among the Rural Families through Motivation and Education

This aspect involved,

1. Educating the rural families

and 2. Introducing improved fuel management practices.

1. Educating the Rural Families

Transfer of appropriate technologies in the Indian Villages is a major challenge. It will help in solving many problems confronting the rural areas, particularly, the fuel shortage. Most of the people in the rural families are illiterate. They follow age old patterns of cooking. To bring an awareness and a change to these families is a Himalayan task. Hence the investigator adopted several motivational techniques to prepare the ground for their adoption of new technologies. They are described in the following paragraphs.

Since fuel management calls for initiative and effort from the women, the Mahalir Manrams (women's clubs) in the villages were contacted, to act as a forum for conducting group meetings and demonstrations. The Presidents of the

Mahalir Manrams were requested to activise and strengthen their members to carry out the programmes chalked out for their benefit.

Realising the significant role that youth can play in rural development programmes science clubs had been formed in all the villages adopted by Sri Avinashilingam Home Science College. One of the main objectives of the Science Clubs is to carry science to the villages. Those clubs were well organised with a President, Secretary and 20 to 25 youth, both boys and girls as members. The Science Clubs were utilised by the investigator as motivating agents to propagate the Science and technological development related to fuel management practices. The Science Club members were first oriented to the appropriate innovations available to the rural families on fuel management.

Home visits were made to the households to discuss with housewives the problems in fuel management and the importance of improving the chulahs, adopting biogas technology and using solar cookers. Special effort was taken to motivate the home makers and heads of families for adopting biogas technology since it involved a large sum of rupees for the construction. The investigator approached the local leaders, Presidents of the Science Clubs and the animators of the adult education centres to get the details of prospective adopters of biogas technology in their respective villages. Visits were made to these households to show the benefits arised by constructing biogas plants.

An exhibition on 'the application of science and technology in Every Day Life' was put up in the Village Marudur, which is centrally situated. In the exhibition, charts, posters and models were exhibited on smokeless chulah, haybox solar cookers, solar dryers, biogas and mud storage devices. Appendices V show the miniature of the posters developed in the local language (Tamil) ~~and~~ used in the exhibition. This exhibition was viewed by many people particularly women and youth who showed great interest in adopting these innovations.

The members were contacted in smaller groups of 15 to 20 for informal talks. The need for introducing smokeless chulah, biogas and solar cookers in the rural households was explained to them by using flash cards.

Field trips were arranged to Sri Avinashilingam Home Science College and to the Tamil Nadu Agricultural University to show the homemakers the different types of energy saving devices in use, the smokeless chulah in the nutritious meal scheme and biogas in the home science residence and solar cookers of different sizes and types were seen by the members. Figure 20 shows the motivational methods adopted to educate the rural homemakers.

2. Introducing Improved Fuel Management Practices

The various methods used for motivation created an awareness among the rural families the need to adopt some innovative method such as smokeless chulah, biogas or solar cooker. As a result of the motivation programme 200 families came forward to adopt smokeless chulahs and 40 families for solar cookers. Twenty families applied to the BDO Karamadai Panchayat Union for loan for construction of biogas plants.

a. Smokeless Chulah

A potter in Marudur Village of Karamadai Panchayat Union was trained and entrusted the work of making the smokeless chulah. Figure 21 show the steps involved in making the chulah by the potter.

The smokeless chulahs were taken from Marudur to the different villages and kept in a common place. The families, willing to install the smokeless chulah were given an identity card. After showing their identity card, they took the chulahs for installation. Instructions had been given

MOTIVATIONAL METHODS ADOPTED

FIGURE 20

PROCESS OF MAKING CHULAH

FIGURE 21

to them clearly on how to install the chulahs and the materials needed for the installation. The families installed the chulahs at their own expense. The households were visited periodically to clear the doubts regarding the installation of the chulahs. As for the care and maintenance of the 'chulah' the homemakers were given the following instructions:

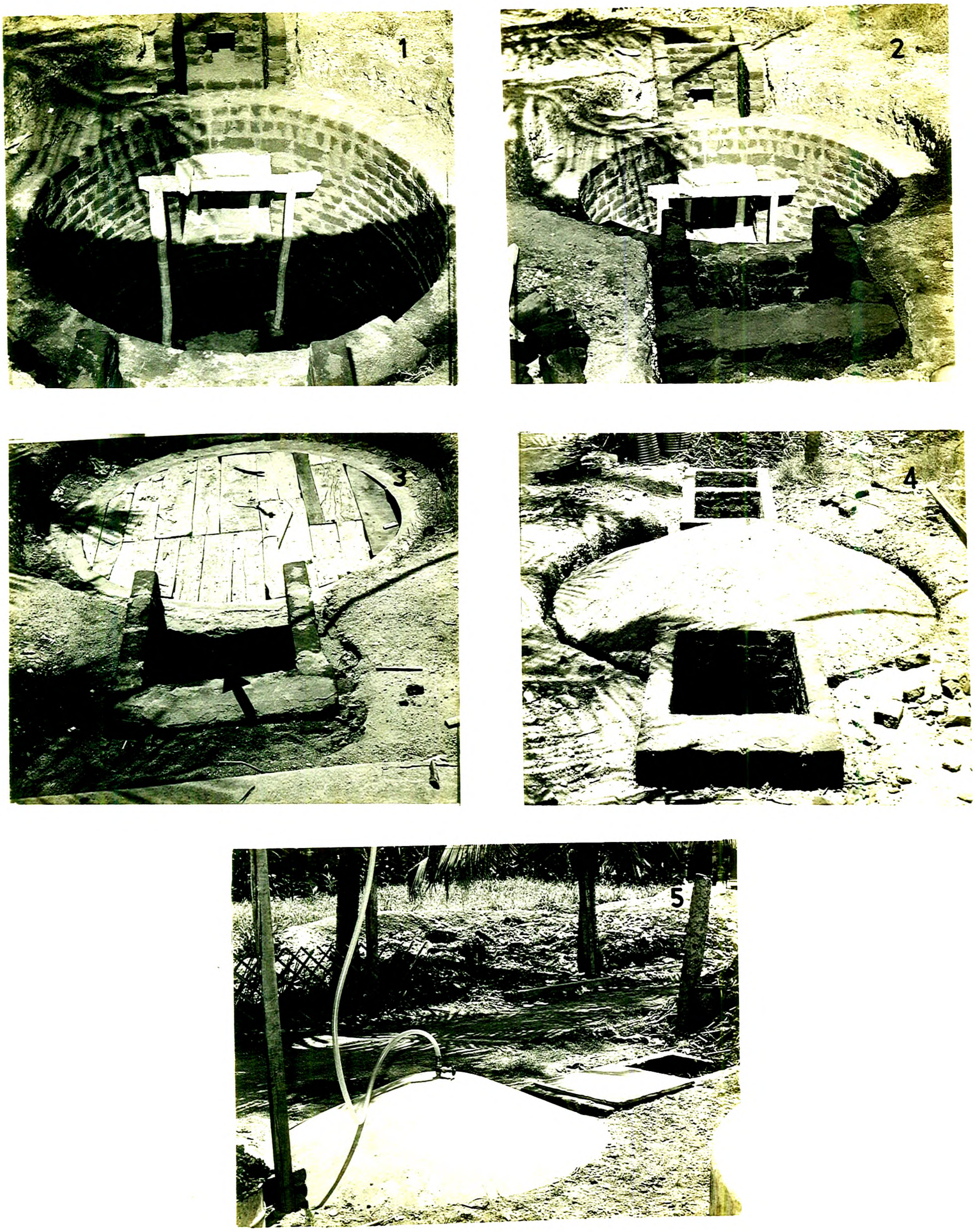
1. Clean the duct and hearth every day and clean the chimney periodically once a month to keep the 'chulah' smokeless.
2. Use both the pot seats for cooking at the same.
3. Not to over stuff the duct with fuel as there must be sufficient space for air to get inside.
4. Plan the work in advance to take full advantage from the chulah.
5. Patch up any cracks as soon as they occur.

b. Biogas Plant

The applications of the 20 families were collected and got processed through the Rural Welfare Officer of the block and handed over to the bank for loan and subsidies through the Block Development Officer. The loans were sanctioned by the Indian Overseas Bank, Vivekanandhapuram and the subsidies were released by the Project Officer, District Rural Development Agency, Coimbatore District.

As the first pre requisite, a training for 10 masons from 5 different villages of Karamadai block was arranged. This was necessary since local untrained masons were engaged for the construction of the biogas plants which led to the constructional defects. The role of the mason is very crucial specially in the construction of dome type of biogas plants, since imperfect construction of masonry and RCC work invariably result in leakages, which, in turn, end in inadequate gas production and ultimate failure of the plant.

The trainees had the opportunity to construct model biogas plants in nine households who volunteered to take up the loan immediately for the construction of biogas plants. The remaining families had started the construction after a month's time utilising the services of the trained masons. However the construction was completed in different timings. Availability of the raw materials and convenience of the plant owners determined the number of days taken for construction. Figure 22 shows the stages involved in constructing a 'Janata Biogas Plant'. Follow up visits were arranged to take the technical personnal of the Biogas section of Coimbatore Collectorate to observe the construction details. For efficient functioning, the following instructions



STAGES IN THE CONSTRUCTION OF JANATA BIOGAS PLANT

FIGURE 22

were given to the adopters of biogas plants:

1. Close the inlet and outlet tank.
2. Mix cowdung and water in the proportion 1:1
3. Clean the cowdung before putting it into the inlet tank.
4. Maintain the volume of the cowdung mixture poured into the tank constant.
5. Check the pipeline periodically for leakage with soapy water.
6. Ventilate well the kitchen.
7. Clean the gas burners once a month.
8. Remove the water logged in the pipe line once a month.
9. Close the regulator properly.
10. Use flat bottom vessel for cooking.
11. Assess approximately the quantum of gas available in the gas plant through the height of the flame and the level of the slurry in the tank.
12. Use the slurry for making compost.

c. Solar Cookers

The solar box type cookers were found to be convenient, compact and easy to use in the households. Sri Ramakrishna Mission Vidyalaya, Perianaickenpalayam was requested to fabricate 40 prototype models based on the

'Universal' brand of solar cooker (box type). Along with the solar cooker two sets of aluminium vessels of 450 grams capacity with tight lids were also given.

Since the concept of utilisation of solar energy was totally new to the rural homemakers, tremendous efforts were taken to expose them to this novel device. The homemakers were given specific guidelines as indicated below for the use and maintenance of the solar cookers:

1. Place the cooker in the open sunshine preferably on a plane surface.
2. Orient the slant face of the cooker towards the sun.
3. Lift up the boost panel so that the sun rays are directed into the cooker and can be absorbed by the inner metallic surface of the blackened tray.
4. To achieve accurate orientation of the cooker move the cooker in such a way that the shadow is completely eliminated on all sides except on the rear side.
5. Place the cooker in this position and keep the flat aluminium containers (coated with black paint) with food and close the top lid.
6. When the food is cooked, wait for 2 to 3 minutes after opening the glass panel.

7. The solar cooker should not be opened frequently since this will result in loss of temperature.
8. The inner black surface of the cooker and the lid, should not be touched by fingers as a safety precaution against burning.
9. The cooker must be kept clean always. In case some food or water gets spilled inside the cooker, it must be cleaned immediately.
10. The cooker should not be left in the rain.

D. Evaluating the Impact of the Adoption of these Improved Fuel Management Practices

This aspect of the study included the following:

1. Eliciting the opinions of the homemakers on the use of the smokeless chulahs, biogas and solar cookers in their homes.
2. Assessing the performance of the smokeless chulahs, biogas and solar cookers.

1. Eliciting the opinions of the homemakers on the smokeless chulahs, biogas and solar cookers

a. Smokeless Chulahs

The 200 homemakers who had received the smokeless chulahs were interviewed to elicit their opinions about the newly constructed chulahs, using an interview schedule specially prepared for the purpose (Appendix VI). A minimum of 20 to 30 days had been allowed after the construction of the chulahs for the homemakers to get used to the cooking with the smokeless chulah. The interview schedule was administered to study details of the money spent for construction, benefits obtained, problems faced and suggestions for further improvement.

b. Biogas

In order to educate the adopters on the correct procedure of operation and maintenance of biogas plants, a discussion meeting was arranged, where technical experts of biogas from Coimbatore Collectorate were invited to discuss the salient points with the users and clear their doubts on the maintenance and operation of the plants. The heads of the families were asked to maintain the expenditure incurred on the construction of the gas plant to assess the cost benefit ratio of biogas plant.

The adopters of biogas were surveyed using an interview schedule (Appendix VII). The survey covered aspects such as background information of the families, details of construction and operation of the biogas plant, uses of gas and slurry, advantages and problems faced during the operation of the plant, and suggestions for improvement.

c. Solar Cooker

Forty homemakers who expressed their willingness to use solar cooker were provided with the cookers. They were asked to maintain the record for the number of days they used the solar cooker for every month. The respondents had been instructed to try their usual menu namely, rice, dhal and vegetable preparation. Apart from this they were asked to prepare as many items as possible, and maintain the record for the same. They were interviewed for their opinions about the use of solar cooker - the satisfactions and limitations experienced (Appendix VIII).

2. Assessing the Performance of the Smokeless Chulah, Biogas and Solar Cookers

a. Smokeless Chulah

Since the assessment of the efficiency of the fuel using smokeless chulah involved scientific record keeping and careful administration, out of the 200 families, 50 were located based on the educational background of the homemaker and interest evinced by her in maintaining records on smokeless chulah. The records maintained together with the observation of the investigator and discussion with the selected homemakers revealed that the average daily consumption of fuel per household was a maximum of 6 kg. of firewood. Therefore 6 kg. of firewood from the stock stored were weighed and given separately to the 50 homemakers before they installed the smokeless chulahs. They were instructed to use fuel from the weighed stack for that day. This was repeated for a period of three days by all the homemakers. The residue was weighed separately each day in order to assess the fuel consumption per household per day. They were also instructed to record the time taken for preparing the items using ordinary chulah. The homemakers were instructed to follow the same procedure for a period of three days, after adopting the smokeless chulah to quantity the firewood needed and the time taken for cooking.

A data sheet as shown in Appendix IX was provided to them for recording the information. The time taken for cleaning the utensils used on the ordinary as well as smokeless chulahs was also maintained by the homemakers in order to find out the time saved if any, after the introduction of the smokeless chulahs.

b. Biogas

In order to record the quantum of biogas required to prepare a day's menu a gas flow meter (INSREF IRO 8 wet type) was used. Homemakers who adopted a routine normal menu of breakfast, lunch, tea and dinner were chosen to assess the sufficiency of biogas for cooking.

The experiment was conducted for nine days (3 days/ household) in the three selected households. This involved the cooking operation done by the homemakers and observations recorded by the investigator. The gas flow meter was set right in the kitchen connecting one of the ends with the gas pipe line and the other end to the burner. The experiment was started after setting the gas flow meter to zero reading. In every household, a whole day menu including breakfast, lunch, tea and dinner was prepared (Figure 23). At the end of each preparation, the reading was noted and the quantum of biogas consumed for preparing the selected menu was calculated. The time taken for preparing each meal of the day was recorded. The required amount of gas for cooking was ascertained by correlating the above readings. The mean biogas requirement for a day's menu for family was calculated by taking the average reading of the experiment done for three days. The data obtained was computed for firewood equivalent.

c. Solar Cookers

A suitable menu was drawn and given to ten selected educated homemakers who had shown great interest in using the solar cookers. Since solar cooker lends itself for preparing lunch and snack items due to the high intensity of solar radiation available between 10 A.M. and 5 P.M.

USING GAS FLOW METER FOR MEASURING BIOGAS
DURING COOKING

FIGURE 23

on bright sunny days the items which could be prepared by boiling and roasting methods were alone suggested to the homemakers with the solar cooker. The homemakers opinion were also taken into consideration in deciding the items to be prepared for three days. They are given below:

I Day: Rice
Drumstick Sambar*
Beetroot Poriyal
Roasted groundnuts

II Day: Rice
Onion Sambar*
Carrot poriyal
Peas sundal**

III Day: Rice
Dhal Kootu
Cluster beans poriyal
Boiled egg
Bengal gram sundal**

---

* Sambar is a dhal preparation mixed with vegetables.

** Sundal is a dhal preparation used for snacks.

They were asked to keep a record of the time taken to complete the cooking using the following format.

Date	Item(s) cooked	Qty. cooked grams	Time when the item was kept in the solar device	Time when the item was removed from the device	Total time taken	Remarks on the cooked product

They were instructed to prepare the same items using ordinary firewood chulah and to record the time taken for cooking and the quantum of firewood used. This procedure was repeated for three days to get a mean score. The records maintained by the homemakers indicated that by using solar cooker effectively how much firewood could be saved over a specific period of time.

Improved fuel management practices were assessed in terms of conservation of time and money, and the forest resources.

IV RESULTS AND DISCUSSION

The results of this study on 'Motivating Rural Families Towards Improved Fuel Management Practices' are presented and discussed under the following headings:

A. Factors associated with the Adoption of Improved Fuel Management Practices,

B. Observations recorded on the Construction, Operation and Maintenance of the Devices Introduced,

C. Outcomes of introducing Improved Fuel Management Practices

and D. Resource Recovery through Improved Fuel Technology.

A. Factors Associated with the Adoption of Improved Fuel Management Practices

The association of factors such as the type of family, size of family, age of the head of the family, educational status of head of the family and homemakers and occupation with the adoption of smokeless chulahs, biogas plants and solar cookers is presented as follows:

1. Type of family Vs adoption

Table XX presents the type of family Vs adoption of improved fuel management practices.

TABLE XX

TYPE OF FAMILY Vs ADOPTION

S. No.	Type of Family	Percentage adopting		
		Smokeless chulahs N:200	Biogas plants N:20	Solar cookers N:40
1	Nuclear	78	65	85
2	Joint	22	35	15

Nuclear type of families, where the decision is taken only by both the head of the family and homemaker was found to be more favourable for introduction of improved fuel management practices. Furthermore the joint family system is disintegrating even in the rural areas.

2. Size of the family Vs adoption

Table XXI presents the size of the family Vs adoption of improved fuel management practices.

TABLE XXI

SIZE OF FAMILY Vs ADOPTION

S. No.	Size of family	Percentage adopting		
		Smokeless chulahs N:200	Biogas plants N:20	Solar cookers N:40
1	1-4	68	40	85
2	5 and above	32	60	15

The adoption of smokeless chulahs and solar cookers was favoured by smaller families whereas the biogas plants were constructed in families with more members.

3. Age of the heads of families Vs Adoption

The age range of the heads of families Vs adoption is shown in Table XXII.

TABLE XXII

AGE RANGE OF THE HEADS OF FAMILIES Vs ADOPTION

S. No.	Age in years	Percentage adopting		
		Smokeless chulahs N:200	Biogas plants N:20	Solar cookers N:40
1	20-35	14	5	75
2	36-45	42	55	20
3	46-55	32	25	5
4	56-65	12	15	--

While the younger generation preferred to experiment with the non conventional practices of solar cooking, the middle age adopted the smokeless chulahs and biogas plants.

4. Educational Status Vs Adoption

Table XXIII presents the educational status of the heads of the families and homemakers who accepted improved fuel management methods.

TABLE XXIII

EDUCATIONAL STATUS Vs ADOPTION

S. No.	Level of Education	Percentage adopting		
		Smokeless chulahs N:200	Biogas plants N:20	Solar cookers N:40
1	Head of the family			
	Illiterate	46	-	-
	Primary school	24	10	20
	Middle school	16	35	40
	Higher Secondary level	14	55	30
	College level	-	-	10
2	Homemakers			
	Illiterate	68	5	-
	Primary school	22	30	10
	Middle school	8	25	60
	Higher Secondary level	2	40	20
	College level	-	-	10

The fact that even illiterate adopted smokeless chulahs, was noteworthy, proving the utility and simplicity of the device, appealing of to all sections of the society.

The extent of adoption of biogas plants and solar cookers varied with the educational status of the head of the family and homemakers pointing out that the operation of biogas and the use of solar cooker demands sound educational backgrounds. As Verma (1978) opines, the awareness and receptivity to new technology, is likely to be favoured more by those having some educational background because of their exposure to development of new ideas.

Occupation Vs Adoption

The occupational structure of the families Vs adoption is presented in Table XXIV.

TABLE XXIV

OCCUPATIONAL STRUCTURE Vs ADOPTION

S. No.	Categories of occupation	Percentage adopting		
		Smokeless chulahs N:200	Biogas plants N:20	Solar cookers N:40
1	Agricultural land owners	20	100	50
2.	Agricultural labourers	52	-	10
3.	Business	18	-	40
4.	Non Agricultural labourers	6	-	-
5.	Others	4	-	-

Smokeless chulahs were adopted by all categories of families probably because of its lowcost and easy construction and operation. On the otherhand, the families who owned biogas plant were only landowners, since possession of sufficient number of cattle, adequate space for construction of the plant and availability of land to use the spent slurry were the pre requisites for adoption of biogas technology.

B. Observations Recorded on the Construction Operation and Maintenance of the Devices Introduced

1. Smokeless Chulah

a. The smokeless chulahs were installed by 90 per cent of the families in the kitchen or in the cooking area allotted in the multipurpose room after demolishing the existing ordinary chulahs. The remaining families had installed the chulahs in a corner of the verandha.

b. All the families had put up their chulahs facing west as per traditional customs prevailing in Tamil Nadu.

c. The chulahs were constructed at a raised level only by 12 per cent of the families for greater convenience and comfort while cooking. The rest of the families had constructed the chulah at lower level to facilitate cooking items such as 'Ragi Kali'* which requires constant stirring. The area beneath the platform was used by them for storing firewood and utensils used for cooking.

d. The households used mud, sand, cement and bricks for constructing the chulahs. In 80 per cent of the households the heads of the families and homemakers supervised the constructional aspects. The installation charges varied from Rs. 15 to Rs: 50 depending on the height of the platform for the chulahs.

e. The first pot seat was mainly used for keeping bigger utensils for cooking rice and other ceral preparations such as 'Iddli,** Ragikali, 'Cholam Dosai'*** and for boiling milk. On the other hand, the second pot seat (smaller in dimension) was being used for preparing vegetables and dhal and also for seasoning purposes. Both the pot seats were simultaneously used as per instructions given.

f. The correct use of the damper is an important factor affecting fuel consumption. Observations indicated, out of the two dampers, all homemakers used the damper at the base of the chimney; only 15 per cent of the

---

* 'Ragi' is one of the locally produced millets. 'Ragikali' is a preparation resembling gruel used in the village households.

** 'Iddli' is a steamed preparation.

*** 'Cholam' is a one of the locally produced millets and the batter made out of it is used for preparing 'Dosai'.

homemakers used the damper in front of the fire box, since the others considered this practice inconvenient.

g. All the homemakers expressed that the smokeless chulahs lent themselves for the use of other fuels also such as barks and twigs, crop waste and coconut shells, besides fuel wood.

h. The smokeless chulahs were cleaned thoroughly, by removing the ashes from the fire box every day after use. The homemakers used 'Kavi'* or 'lime stone' to maintain red and white colours in the smokeless chulahs respectively. Smearing with cow-dung and putting 'Kolam'** was also practiced by some families.

i. The chimney pipe was cleaned periodically once in fifteen days for efficient functioning of the chulah.

2. Biogas Plants

a. All the biogas plants were constructed on an elevated ground in order to avoid the seepage of water near the plants and easy draining of rain water. The plants

---

* 'Kavi' is a red colouring powder used for floral decorations.

** 'Kolam' is a common floral decoration of Tamil Nadu.

were constructed in such a way without any shading effect of big trees or a tall building nearby.

b. Space was no problem for any of the households since all had their own houses with a fairly large house site area of more than 100 sq.m. Sixty five per cent of the biogas plants were constructed at a proper distance of within 25 metres from the kitchen, to ensure sufficient gas production. All the biogas plants were located within 35 metres from the cowshed to facilitate easy transport of cowdung from the cowshed.

c. Since the motivational programme highlighted the importance of 'Janata Model' biogas plants (Dome type) over the conventional KVIC model, all the families had constructed the Janata Model biogas plants. The capacity of the gas plant constructed was 6 cu.m irrespective of the number of cattle owned and size of the family. It was revealed that the income of the family did not play an important role in deciding the capacity of the biogas plants constructed.

d. Most of the biogas plants (80 per cent) were completed within a period of three months. In other cases the period taken to complete the construction was about six months due to the delay in getting the materials such as cement.

e. The total cost of construction varied from Rs: 7000-7500 and the families received loans from Indian Overseas Bank Branch, located at the premises of Sri Avinashilingam Krishi Vigyan Kendra, Vivekanandapuram. A sum of Rs: 2500 was received by the families as subsidy.

The break up of the construction cost was as follows:

1. Building material (Brick, cement, sand and iron rods)	...	59 per cent
2. Accessories (Pipes and gas stove)	...	27.5 per cent
3. Labour charges	...	13.5 per cent

Nearly 60 per cent of the money has been spent on building material, since the whole structure involves masonary construction. The cost of the pipe line varied with the distance of the biogas plant from the kitchen.

f. The quantum of cowdung used for initial loading of the gas plant varied from 6000 to 7000 kg. A quantum of 160 to 170 kg of dung per day was fed into the plant. The number of cattle possessed, ranged from 9 to 20 ensured adequate supply of cowdung to feed the plants. In 60 per cent of the households, men labourers were reported to be mixing the cowdung with water and in 25 per cent women labourers; and in the rest adolescents were preparing the slurry to be fed into the plants. The labourers working in their own farm were utilised for the preparation of dung mixture. The cowdung with water was mixed in the ratio of 1:1 to get the optimum production of gas. The feeding was done once a day most preferably in the morning.

g. All the families used biogas for cooking purposes. In addition 20 per cent of the families used the biogas for heating water. Though the biogas could be used for lighting and agricultural operations, the priority was given to the household cooking indicating the necessity to relieve the women from the drudgery of smoke and also to save fuelwood for cooking.

h. The families were following certain precautions for efficient operation of the biogas plants:

1. Removing the stalks and solid materials from the cowdung before mixing.
2. Mixing cowdung with water thoroughly in the proportion of 1:1.
3. Regular feeding of the cowdung.
4. Removing the accumulated water from the pipeline.
5. Cleaning the burners frequently.
6. Checking the outlet of the slurry.

3. Solar Cookers

a. The Solar Cookers were reported to be used by the

the families between 10.00 A.M. and 5 P.M. on the sunny days by the homemakers. The solar cookers were brought out and placed in the front yard by 64 per cent of the homemakers, and at the back yard by 36 per cent of the homemakers at the time of cooking.

Table XXV presents the number of days on which the solar cookers was used by the homemakers during the experimental period of six months (January to June, 1985).

TABLE XXV

NUMBER OF DAYS THE SOLAR COOKERS WERE USED

Month	Number of Homemakers using the solar cookers N:40	Mean number of days used
January	10	12
February	22	14
March	18	15
April	19	21
May	24	25
June	12	11

The solar cookers were used only for 12 days on an average in January and in a maximum number of 21 and 25 days in the months of April and May respectively. This may be due to the high intensity of solar radiation during these two months.

b. All the selected families used solar cooker whenever possible. The time taken to cook the foods varied with the quantum of food stuffs used and with the solar intensity of the day.

c. Apart from cooking, 55 per cent of the homemakers used the solar cookers also for drying various items such as chillies, maize, corriander seeds, gingelly seeds and 'maruthani' leaves.

C. Outcomes of Introducing Improved Fuel Management Practices

1. Smokeless Chulah

Several advantages were reported by the adopters in using the improved chulah (Table XXVI).

TABLE XXVI

ADVANTAGES OF USING SMOKELESS CHULAH

S.No.	Advantages	Percentage of home-makers stating N:200
1	Eliminates smoke from the kitchen	100
2	Keeps the kitchen wall clean at lower costs	100
3	Lends for the use of all types of fuels	100
4	Gives soot free utensils	99
5	Saves time in cleaning utensils	99
6	Foster better family relationship	97
7	Helps to prepare extra items	97
8	Saves time in meal preparation	96
9	Saves fuel wood	96
10	Simple Technology	95
11	Cheaper cost of construction	94
12	Reduces the attention given to the chulah	94
13	Removes eye strain	93
14	Removes the drudgery in cooking	92
15	Minimises time spent in fuel collection	75

All the homemakers spontaneously mentioned the benefit of smoke free kitchen which enable them to perform cooking in hygienic, pleasant atmosphere. Providing opportunities for all the family members to remain inside the multipurpose room (now free from smoke), this simple device helped to develop better family relationships. Seventy five per cent of the homemakers mentioned the saving of trips for fuel collection.

When asked to quantify the fuel saved in using the smokeless chulah, the data as presented in Table XXVII were obtained.

TABLE XXVII

FIRE WOOD CONSUMPTION BEFORE AND AFTER INTRODUCTION OF SMOKELESS CHULAH AS POINTED OUT BY THE HOMEMAKERS

S. No.	No. of family members	Mean fuel consumption per day in kg		
		Ordinary chulah	Smokeless chulah	Fire wood saved per day for the family
1	2	3.25	3.00	0.25
2	3	4.50	4.00	0.50
3	4	4.75	4.25	0.50
4	5	5.50	5.25	0.50
5	6	5.50	5.25	0.25
6	7	5.75	5.20	0.50

The Table indicates that a saving of 0.25 to 0.50 kg. of fire wood per day per family could be realised through the use of smokeless chulahs. Taking the prevailing price of fire wood to be 80 paise per kilogram, a saving of Rs: 6 to Rs: 12 per month was possible, besides getting other benefits.

As for saving of time, 90 per cent homemakers saved 40 minutes of their cooking time everyday due to the higher thermal efficiency of the smokeless chulah. Preparation of two items simultaneously was an added advantage.

However, certain problems were reported to be encountered by the users of the smokeless chulah (Table XXVIII).

TABLE XXVIII

PROBLEMS FACED IN USING SMOKELESS CHULAH

S.No.	Problems faced	Percentage of homemakers stating N:11
1	Big utensils could not be used since the pot hole was small	100
2	Removal of soot from the chimney pipe is difficult	73
3	Leakage of water through the chimney pipe	64
4	The distance between the second pot seat and the chimney is less	46

The problems though, expressed only by a few homemakers, are worthy of consideration.

2. Biogas Plants

The benefits realised by the homemakers by adopting the biogas technology are mentioned in Table XXIX

TABLE XXIX

BENEFITS DERIVED FROM THE BIOGAS PLANTS

S.No.	Benefits	Percentage of Families reporting N:20
1	Supplies efficient fuel gas	100
2	Supplies rich manure reducing the money spent on chemical fertiliser	100
3	Avoids smoke and smell	95
4	Maintains the surroundings clean	90
5	Conserves time and energy in cooking food and cleaning utensils	90
6	Reduces monthly expenditure on fuel	80
7	Facilitates getting more time to relax	80
8	Prevents growth of flies, mosquiotes and weeds in the open slurry	75
9	Reduces the eye strain	70

The major benefits were in terms of efficient fuel gas and fertiliser as realised by homemakers. No homemaker expressed problems in the use of the newly constructed biogas plants.

3. Solar Cookers

The homemakers mentioned their opinions on solar cooking, as found in Table XXX

TABLE XXX

OPINION ON SOLAR COOKING

S.No.	Opinion	Percentage stating N:40
1	Novel way of cooking	100
2	No fuel consumption	100
3	Pollution free cooking	96
4	Easy to clean the utensils	84
5	Utilising available resources	60
6	Eliminates the problem of collecting and storing fuels	56
7	Easy to operate the cooker	52

More than 50 per cent of the homemakers realised the various benefits of utilising solar energy for cooking. The novel way of cooking was fascinating to the rural homemakers. Ninety six per cent of the homemakers mentioned the solar cooking is pollution free as the cooking is done in an enclosed box.

Table XXXI gives the items cooked and the time taken to cook the selected items in the solar cookers.

TABLE XXXI

TIME TAKEN TO COOK THE SELECTED ITEMS IN THE SOLAR COOKER

S.No.	Item cooked	Quantity in gm	Mean time taken Hrs. Mins.
1	Rice	400	2.50
		300	2.05
		200	2.00
		100	1.10
2	Redgram dhal	250	3.15
		150	2.30
3	Green gramdhal	250	2.10
		200	2.00
4	Whole green gram dhal	250	2.50
		200	2.35
5	Bengal gram dhal	300	2.50
6	Cowpeas	100	1.25
7	Dried peas	100	2.07
8	Channa	100	1.45
9	Carrot	300	3.40
10	Beetroot	300	3.00
11	Potato	150	2.00
12	Beans	150	2.00
13	Cluster beans	150	2.00
14	Broad Beans	100	2.00
15	Yam	100	2.52
16	Cabbage	100	2.50
17	Sweet potato	250	2.30
18	Roasting of groundnuts	100	1.00
19	Egg	4 Nos.	0.40

The Table indicates the homemakers cooked several items by using solar cookers. The data shows at a glance that comparatively the solar cooking takes more time.

The homemakers were not satisfied with some of the products cooked in the solar cooker and their specific remarks are given below (Table XXXII).

TABLE XXXII

ITEMS NOT PREFERRED BY THE HOMEMAKERS IN SOLAR COOKING

S. No.	Item	Reasons
1.	Horse Gram	Not cooked to the desired texture
2.	Brinjal	Colour changed and tastes bitter
3.	Ladiesfinger	Slimy nature of the product
4.	Plantain	Not tasty
5.	Snakegourd and Ridge gourd	Not cooked to the desired texture

Eventhough the solar cooker is preferred to cook certain items the homemakers did not favour the use of the cooker for certain other items mainly vegetables.

The limitation pointed out by the homemakers in using solar cookers were as follows:

1. Bringing the solar cooker out of the house was very difficult due to its heaviness.

2. It took comparatively more time to cook the items in the solar cooker.
3. Cooking depends predominantly on solar intensity, which they were unable to judge. It cannot be used during nights or in rainy seasons.
4. Solar cooking cannot completely replace cooking with fire wood or other fuels.
5. Large quantity of food cannot be cooked, owing to the small size of the cooker.
6. Frying cannot be done.
7. The appearance of certain cooked products was changed (darkened).
8. Solar radiation affects the eyes and the body since solar cooking demands working in the hot sun.
9. Delicate parts of the cooker like glass are easily breakable.

The practice of using improved devices and methods in the rural households have brought qualitative change in the appearance of the house especially kitchen. The drudgery of smoke is eliminated through the use of smokeless chulah, resulting in a much cleaner kitchen. The accumulated cowdung near the house site has been effectively transferred into the biogas plants making the surroundings neat and tidy thus promoting healthier and happier living.

BEFORE | AFTER

SMOKY KITCHEN

CLEAN KITCHEN

SOOT DEPOSITED UTENSILS

CLEAN UTENSILS

BEFORE AND AFTER INTRODUCING IMPROVED FUEL MANAGEMENT PRACTICES

FIGURE 24

BEFORE

AFTER

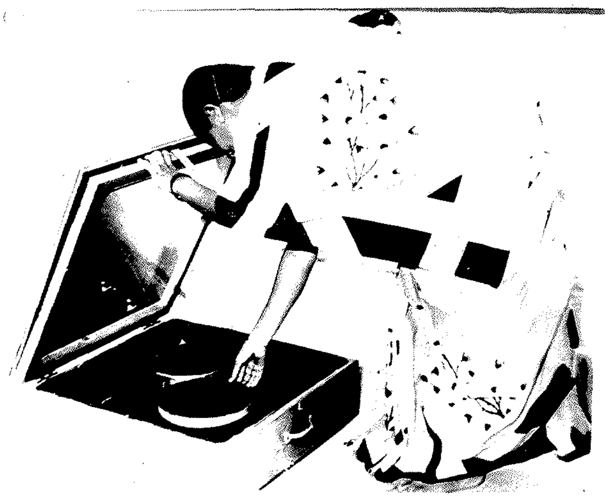
UN-UTILISED COWDUNG

COWDUNG UTILISED IN BIOGAS PLANT

USING FIRE WOOD

USING BIOGAS

USING PRIMITIVE DEVICE



USING SCIENTIFIC DEVICE

BEFORE AND AFTER INTRODUCING IMPROVED FUEL MANAGEMENT PRACTICES

FIGURE 25

The homemakers who have been toiled using age old methods of cooking with primitive chulahs have been exposed to the novel way of cooking using solar cooker thus utilising the available resources. Figures 24 and 25 clearly depict the before and after adopting the improved fuel management practices.

D. Resource Recovery through Improved Fuel Technology

The resource recovery in terms of fuel, money and time resulting from the introduction of the improved fuel management practices is discussed in the subsequent paragraphs.

1. Smokeless chulah

a) Fuel saved with the use of smokeless chulah

Table XXXIII and Table XXXIV and Appendix X show the fuel wood consumption before and after introducing the smokeless chulahs in the 50 households where indepth studies were conducted.

TABLE XXXIII

FUEL WOOD CONSUMPTION IN THE ORDINARY Vs SMOKELESS CHULAHS WHEN TWO MEALS ARE PREPARED

Total Number = 26 Families

S. No.	No. of members in the family	No. of families	Mean fuel consumption per day per family in kg.			Mean fuel consumption per day per capita in kg.		
			Ordinary chulah	Smokeless chulah	Fuel saved	Ordinary chulah	Smokeless chulah	Fuel saved
1	2	2	2.65	2.10	0.55	1.325	1.050	0.275
2	3	4	2.96	2.38	0.58	0.986	0.793	0.193
3	4	5	3.82	3.27	0.55	0.955	0.817	0.138
4	5	5	4.42	3.89	0.53	0.884	0.778	0.106
5	6	5	5.43	4.91	0.52	0.905	0.818	0.087
6	7	3	5.72	5.32	0.40	0.817	0.760	0.057
7	8	2	6.12	5.70	0.42	0.765	0.712	0.053
							Mean value	0.130

TABLE XXXIV

FUEL WOOD CONSUMPTION IN THE ORDINARY Vs SMOKELESS CHULAHS WHEN THREE MEALS ARE COOKED

Total Number: 24 Families

S. No.	No. of members in the family	No. of families	Mean fuel consumption per day per family in kg			Mean fuel consumption per day per capita in kg		
			Ordinary chulah	Smokeless chulah	Fuel saved	Ordinary chulah	Smokeless chulah	Fuel saved
1	2	3	3.13	2.63	0.50	1.565	1.315	0.250
2	3	5	4.09	3.59	0.50	1.363	1.196	0.167
3	4	5	4.40	3.89	0.51	1.100	0.972	0.128
4	5	6	5.14	4.71	0.43	1.028	0.942	0.086
5	6	3	5.63	5.16	0.47	0.938	0.860	0.078
6	7	2	5.97	5.42	0.55	0.852	0.774	0.078
						Mean value		0.131

The mean per capita saving effected in fuel wood used as a result of adopting smokeless chulahs amounted to be 0.130 kg. per day per person for the families cooking two meals a day and 0.131 kg. per day per person for those following a three meal pattern.

Taking into account the average size of the rural household for Tamil Nadu* (i.e., 4.46) the saving of fuel per family per annum was estimated (0.130 kg. x 4.46 x 365 days) to be 211.627 kg. (11.4 per cent of the fire wood consumption). The smokeless chulah results in a saving of 11.4 per cent in the present consumption of fuel wood per family. The consequent saving in fuel wood consumption for the nation would be 15.20 million tonnes per year (11.4 per cent of 133 million tonnes) if all the families adopt smokeless chulah. Thus with an initial expenditure of Rs:50 for a smokeless chulah, much saving in fuel cost is effected, contributing to the fuel and forest economy of the nation.

b. <u>Money saved with the use of smokeless chulah</u>

The saving of fire wood effected by using smokeless chulah is amounted to 212 kg. per family per annum. Based

---

* Ref: Report based on data collected through the State Sample of National Sample Survey - 32nd Round 1977-'78 issued by the Department of Statistics, Madras, 1979, p.16.

on the prevailing prices of fire wood at the rate of 80 paise per kilogram, the saving of money on fuel would be Rs. 170 per family per annum.

3. Time Saved with the Use of Smokeless Chulahs

Table XXXV gives the mean time expenditure in cooking food and cleaning utensils while using ordinary and smokeless chulahs.

TABLE XXXV

TIME EXPENDITURE IN COOKING FOOD AND CLEANING UTENSILS IN ORDINARY AND SMOKELESS CHULAHS

S.No.	Activity	Mean time Expenditure per family per day		
		In ordinary chulah	In smokeless chulah	Difference
		Minutes	Minutes	Minutes
1	Cooking Food	199.24	167.18	32.06
2	Cleaning utensils	14.8	8.08	6.72
	Total	214.04	175.26	38.78

It was interesting to note that the mean saving of time for a homemaker in cooking food and cleaning cooking utensils amounted to be 38.78 minutes per day or 236 hours per annum (10 man days per annum) which the homemakers may utilise for productive purposes.

Figure 26 shows the resources recovered by the families with the use of smokeless chulah.

2. Biogas Plant

a. Recovery of fuel wood

The fuel wood recovered by using biogas as fuel in the families was computed, based on the consumption of firewood prior to the introduction of biogas plants. Table XXXVI gives the consumption of fire wood by the selected families before using biogas for cooking.

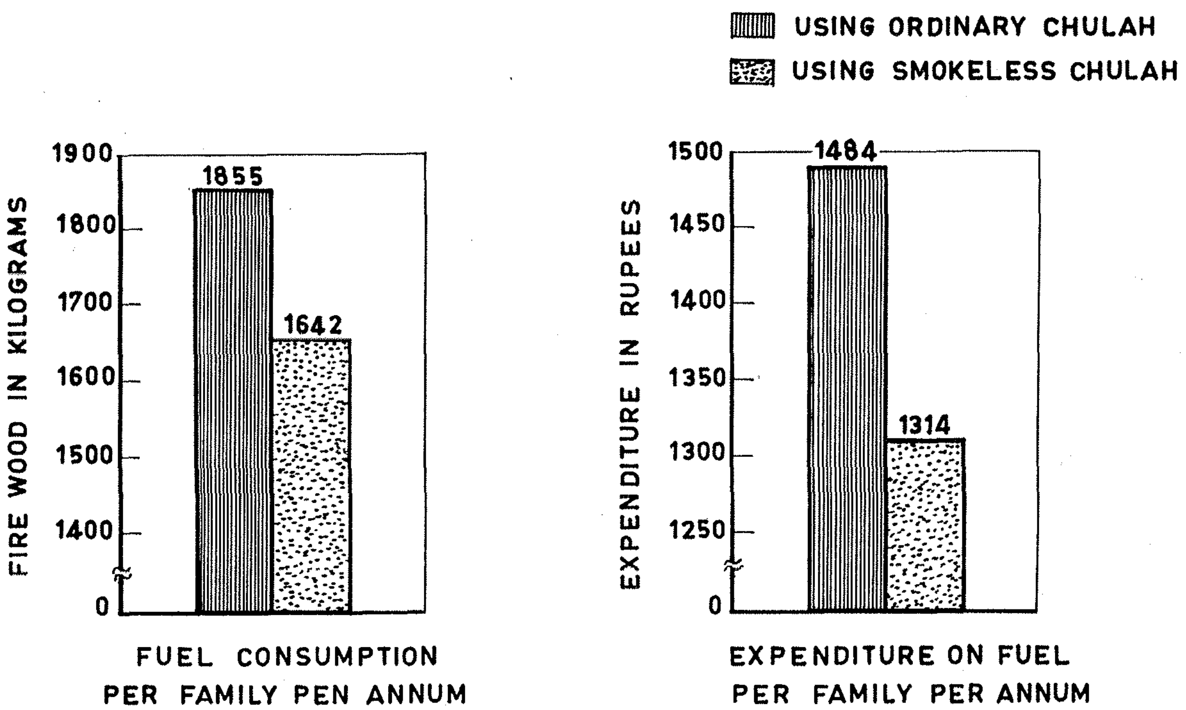
TABLE XXXVI

FIRE WOOD CONSUMPTION BY THE SELECTED FAMILIES BEFORE USING BIOGAS FOR COOKING

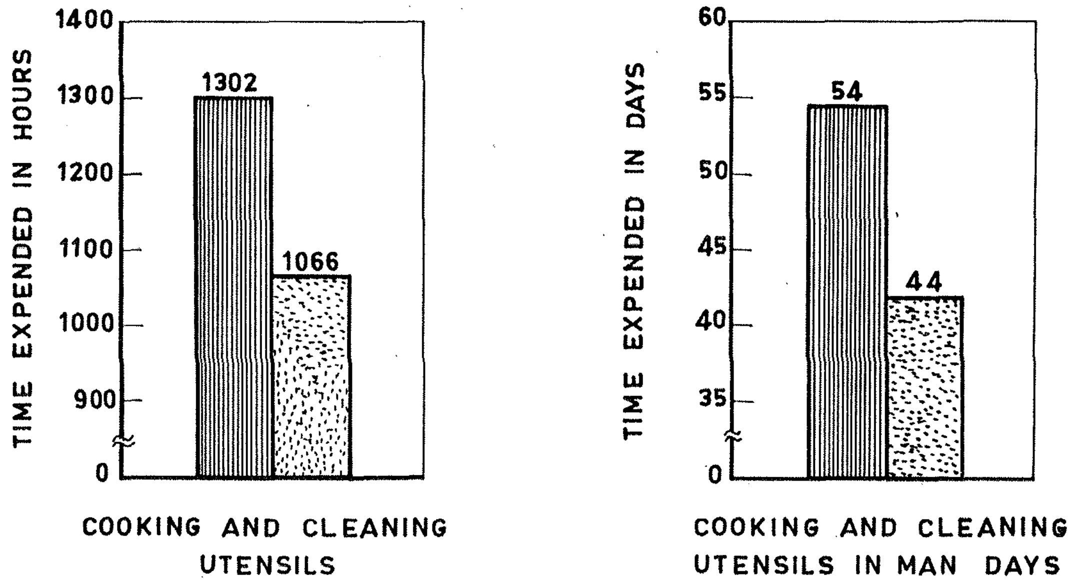
S. No.	Number of members	Mean fire wood consumption per day in kg.	
		For the Family	Per Capita
1	5	5.20	1.04
2	5	5.10	1.02
3	5	5.60	1.12
	Mean value	5.30	1.06

The mean fire wood consumption per day per capita was 1.06 kg.

After constructing the biogas plants, the families



(a) FUEL CONSUMPTION AND EXPENDITURE ON FUEL PER FAMILY PER ANNUM



(b) TIME EXPENDED PER ANNUM FOR COOKING AND CLEANING UTENSILS BY A HOME MAKER

BENEFITS OF USING SMOKELESS CHULAHS

FIGURE 26

used only biogas for cooking. The volume of biogas needed for cooking a whole day's menu was assessed by using the Gas flow meter (Table XXXVII).

TABLE XXXVII

VOLUME OF GAS CONSUMED FOR THE PREPARATION OF THE DAY'S MENU

S. No.	Item	Gas Consumption in Litres			
		Family 1	Family 2	Family 3	Mean
1	Breakfast	273.0	268.0	256.0	265.6
2	Lunch	429.6	427.3	492.6	449.8
3	Tea	175.6	160.0	180.6	172.1
4	Dinner	254.0	309.4	344.3	302.5
	Total	1132.2	1164.7	1273.5	1190.0

The mean volume of biogas required to prepare a day's menu for a family was found to be 1190 litres or 41.65 cu.ft. and the per capita was estimated to be 238 litres or 8.4 cu.ft. This data correlates well with the existing data of Khadi and Village Industries Commission (8 cu.ft. per capita).

b. Recovery of Money

The comparison of fuel consumption per family per annum while using fire wood and biogas is presented in Table XXXVIII.

TABLE XXXVIII

COMPARISON OF FUEL CONSUMPTION PER FAMILY PER ANNUM WHILE USING FIREWOOD AND BIOGAS

S. No.	Fuel	Per capita consumption per day	Consumption per family per day	Consumption per family per annum	Money value in Rs:
1	Firewood (kg.)	1.06	5.30	1934.5	1547.60
2	Biogas (litres)	238	1190	434350 * or 434.35 cu.m.	1525.60**

* 1 cu.m = 35 cu.ft = 1000 litres.

Ref. Myles, R.M.A. 'Report on Biogas Technology' Action for Food Production, New Delhi, pp.22-24.

** Value based on the capital investment for constructing biogas plants.

Thus by installing a $6m^3$ biogas plant, with the initial cost of Rs:7,500, fire wood of the value of Rs:1,547.60 per annum could be saved. Taking into consideration the subsidy available, the family has to repay only Rs:5,000 as loan. A considerably long repayment period of 5-7 years is given for the adopters, the interest rate being only 10.5 per cent. Thus a family has to repay approximately

Rs:7,625 over a period of five years or Rs:1,525 per annum (Capital plus interest).

In addition to the saving of 1935 kg. fuel wood per annum 21.90 tonnes worth of farmyard manure could be obtained from the biogas plant, saving considerably on the fertiliser costs for the farmers. From these savings, the loan dues for biogas plants could be easily repaid within the stipulated time. Thus the biogas plants constructed proved to contribute to the fuel economy of the household, besides offering several other advantages.

3. Time Saved while Using Biogas as Fuel

The average time taken to prepare whole day's menu using fire wood and biogas as fuel are given in Table XXXIX.

TABLE XXXIX

AVERAGE TIME TAKEN TO PREPARE THE DAYS MENU USING FIRE WOOD AND BIOGAS AS FUELS

S. No.	Items	Time taken in minutes								Difference in minutes
		Using Fire wood				Using Biogas				
		1	2	3	Mean	1	2	3	Mean	
1	Break fast	58	60	61	60	48	55	59	54	6
2	Lunch	97	86	98	94	85	78	85	83	11
3	Tea	40	38	35	38	38	36	32	35	3
4	Dinner	55	52	60	56	51	50	55	52	4
	Mean time taken to cook a day's menu				248				224	

The time taken to prepare a day's menu for a family of five members was about four hours. The data shows that only a negligible amount of time was saved by using biogas as fuel over the ordinary chulah. By careful planning of the menu and cooking schedule the time could further be reduced to three hours or even less.

3. Solar Cookers

Table XL indicates the time taken to prepare the selected items by using solar cooker and ordinary chulah.

TABLE XL

COMPARISON OF TIME TAKEN TO PREPARE THE ITEMS USING SOLAR ENERGY AND FIREWOOD

S. No.	Items cooked	Quantity in grams	Time Taken in minutes: Solar cooking* Hrs.	Solar cooking* Mts.	Use of fire wood Hrs.	Use of fire wood Mts.	Difference Hrs.	Difference Mts.
I	Rice Red gram dhal Beetroot	400 100 150	2	00	1	00	1	00
	Roasting groundnuts	200	1	00	0	10	0	50
II	Rice Redgram dhal Carrot	400 100 150	2	40	1	00	1	40
	Peas	100	1	40	0	25	1	15
III	Rice Redgram dhal Cluster beans	300 150 100	2	30	1	00	1	30
	Egg	4 Nos.	0	40	0	10	0	30
	Bengal gram dhal	150	1	40	0	30	1	10

* An addition of 15 minutes is required for seasoning the items cooked by solar cooker.

The time taken to cook items for lunch ranged from 2 hours to 2 hours and 40 minutes. An addition of 15 minutes were required to complete the cooking namely frying or seasoning. The preparation of snacks required one hour to one hour and forty minutes depending on the items. Though apparently solar cooking requires a lot of time, 50 per cent more than cooking the same menu over fire wood, there is the advantage of less attention for cooking required by the home-maker. The time thus saved could be used by the homemakers to complete the other household chores while food is being cooked in the solar cooker.

b. Fuel and Money saved through Solar cooker

The quantum of fire wood that was needed to prepare these items on an average was 0.8 kg. per day using ordinary chulah. This could be saved if solar cooker was also used for cooking the menu. This results in a saving of 160 kg. of fire wood per family per annum if solar cooker is constantly used on all the bright sunny days (200 days in a year).

Thus the improved fuel management practices help in conserving the valuable forest resources besides recovering human and material resources of the family.

V. SUMMARY AND CONCLUSION

The world wide energy crisis has brought increasing emphasis upon the use of renewable sources of energy. This study made an attempt to motivate a selected group of rural households through education, towards adopting appropriate fuel management practices such as the use of smokeless chulahs and biogas and solar cookers. Twelve villages in Karamadai Panchayat Union, Coimbatore District were selected for this project.

A preliminary survey was conducted in 914 households drawn from the 12 villages to understand the existing fuel management practices. A large majority, of the families (93 per cent) were nuclear, indicating the decline of the joint family system. The analysis of the population showed that 21 per cent were adolescents and 49 per cent were adults, showing the high work force potential. More than 70 per cent of the sample were illiterate. Their predominant occupation centred around agriculture.

Firewood, barks and twigs, specific crop wastes such as cotton stalks and chilly plant waste were the fuels used by the households. Their work pattern indicated that 11 per cent of the time of the households had been spent in collecting fuels which needed walking about 2 to 3 km. every day.

All the homemakers used the ordinary chulah only. Sixty nine per cent used two pot seated ordinary chulahs, while 31 per cent used one pot seated chulahs. Eighty nine per cent had the chulahs at floor level and the remaining had them at higher working levels.

Aluminium was found to be commonly used for cooking, replacing the traditional mud-pots. The homemakers reported that they encountered several problems in using the ordinary chulahs. The major problems mentioned were smoke emission, soot deposition on the utensils and walls, difficulty in cleaning the utensils, frequent attention needed by the chulah, and high cost of the fuel and its wastage. Ninety five per cent of the homemakers expressed their desire to change the traditional chulah to overcome the problems associated with it.

Experiments were therefore conducted at the laboratory level to select utilising some of the existing devices to evolve a smokeless chulah, biogas technology and solar cooker suitable for introduction into the rural households. Based on the findings, the 'Avinashilingam' model for smokeless chulah, Janata model for biogas plant and Box type for solar cooker were chosen, as they proved the best among the various models studied.

Later, after the introduction of the devices, the quantum of fuel wood consumed was noted in the case of households adopting smokeless chulah and solar cooker. A gas flow meter was used to measure the volume of biogas consumed for cooking.

The following are the findings of the evaluation:

Factors such as size of the family, type of family, occupational structure, education of both head of the family and homemaker had a definite influence on the adoption of a new technology. More number of nuclear and small families favoured the new innovative methods. The agricultural families alone showed interest in the construction of biogas plants since the spent slurry could be effectively used in their fields as fertilizer. Educated homemakers showed great interest in experimenting with solar cookers.

Smokeless Chulah

1. All the homemakers expressed that the newly constructed smokeless chulahs lent themselves for the use of barks, twigs, crop waste, and coconutshells besides firewood.

2. Ninety per cent of the homemakers expressed that 40 per cent of the time could be saved, while using smokeless chulah, since two items can be cooked simultaneously.

3. Clean environment, better family relations, reduction in fuel cost and elimination of drudgery for the homemaker in the process of cooking food and cleaning utensils were the benefits according to the homemakers as a result of using smokeless chulah.

4. The mean per capita saving in fuel consumption was found to be 0.130 kg. per day for the families cooking two meals a day and 0.131 kg. per day for those following three meal pattern. The total consumption of firewood per family per annum was found to be 1855 kg. in the ordinary chulah and 1643 kg in the smokeless chulah.

5. The saving of fuel wood per family per annum, calculated based on the average size of the rural household for Tamil Nadu i.e., 4.46 (obtained from the reports of the Department of Statistics) was found to be 212 kg. Taking into account the national estimate of the present fuel wood consumption to be 133 million tonnes, a saving of 15.20 million tonnes would be effected, if all the households in India using fuel wood for cooking, adopt the smokeless chulah.

6. Considering the prevailing prices of firewood the saving of money on fuel worked out to be Rs:170 per family per annum for which an initial investment of only Rs:50 was needed for the smokeless chulah.

7. The time saved in cooking food and cleaning cooking utensils by the homemakers amounted to be 38.78 minutes per day. Consequently, 236 hours or ten man days could be saved per annum which could be utilised by the homemaker for productive purposes.

Biogas Plants

Encouraged by the motivational programme, 20 families constructed 6 m^3 Janata model biogas plants to utilise the cowdung available in an efficient way. The biogas plants were constructed on an elevated ground within 35 metres from the cowshed to facilitate easy transport of cowdung from the cowshed. Sixty per cent of the expenditure were on building materials since the whole structure involves only masonry construction. The number of cattle possessed ranged from 9 to 20 which ensured adequate supply of cowdung to feed the plants. A quantum of 160 to 170 kg. of cowdung mixed with water in the proportion 1:1 was fed into the plant every day to get optimum gas production. The Biogas was used mainly for cooking purposes. Twenty per cent of the families used the biogas for heating water. The use of biogas for cooking resulted in several advantages as given below:

1. The biogas plant supplies efficient fuel gas and manure, gives cleaner environment, avoids smoke and smell,

gives more time to relax.

2. The homemakers mentioned that their kitchen were much cleaner than before.

3. The analysis indicated that for cooking a day's menu 1190 litres of biogas were needed for a family of five members. The per capita consumption was estimated to be 238 litres or 8.4 cu.ft. These families consumed on an average 5.3 kg. of firewood for cooking a day's meno. A quantum of 1935 kg. of firewood worth Rs:1547 could be saved per annum per family, by installing biogas plants.

4. In addition to the saving of considerable amount of firewood, 21.90 tonnes of farm yard manure could be obtained from the biogas plant saving considerably on the fertilizer costs for the farmers.

5. The time taken to prepare a day's menu for a family of five members was about 224 minutes, when biogas was used as fuel, and 248 minutes when fire wood was used as fuel. Much more time could be saved by careful planning of the menu and cooking schedule.

Solar Cookers

The solar cookers were reported to be used by the families between 10.00 A.M. and 5 P.M. on the bright sunny days. The solar cookers could be used only for 12 days on an average in January and a maximum number of 21 and 25 days in the months of April and May respectively, due to the high intensity of solar radiation during the summer months.

Rice, dhal and vegetables were cooked by using solar cooker. Solar cookers were used also for drying various items such as chillies, maize, corriander seeds, gingelly seeds and 'maruthani' leaves. More than 50 per cent of the homemakers realised the various benefits of utilising solar energy for cooking. The novel way of cooking was fascinating to the rural homemakers:

1. Cooking by using solar energy took more time on a comparative basis.

2. Eventhough the solar cooker were preferred to cook certain items, the homemakers did not favour the use of the solar cooker for certain other items mainly, country vegetables, since the appearance of the products was changed considerably.

3. The heavy weight of the cooker, inability to use it in the night, lack of feasibility to cook large items and intermittent nature of sunlight were the limitations pointed out by the homemakers in using solar cookers.

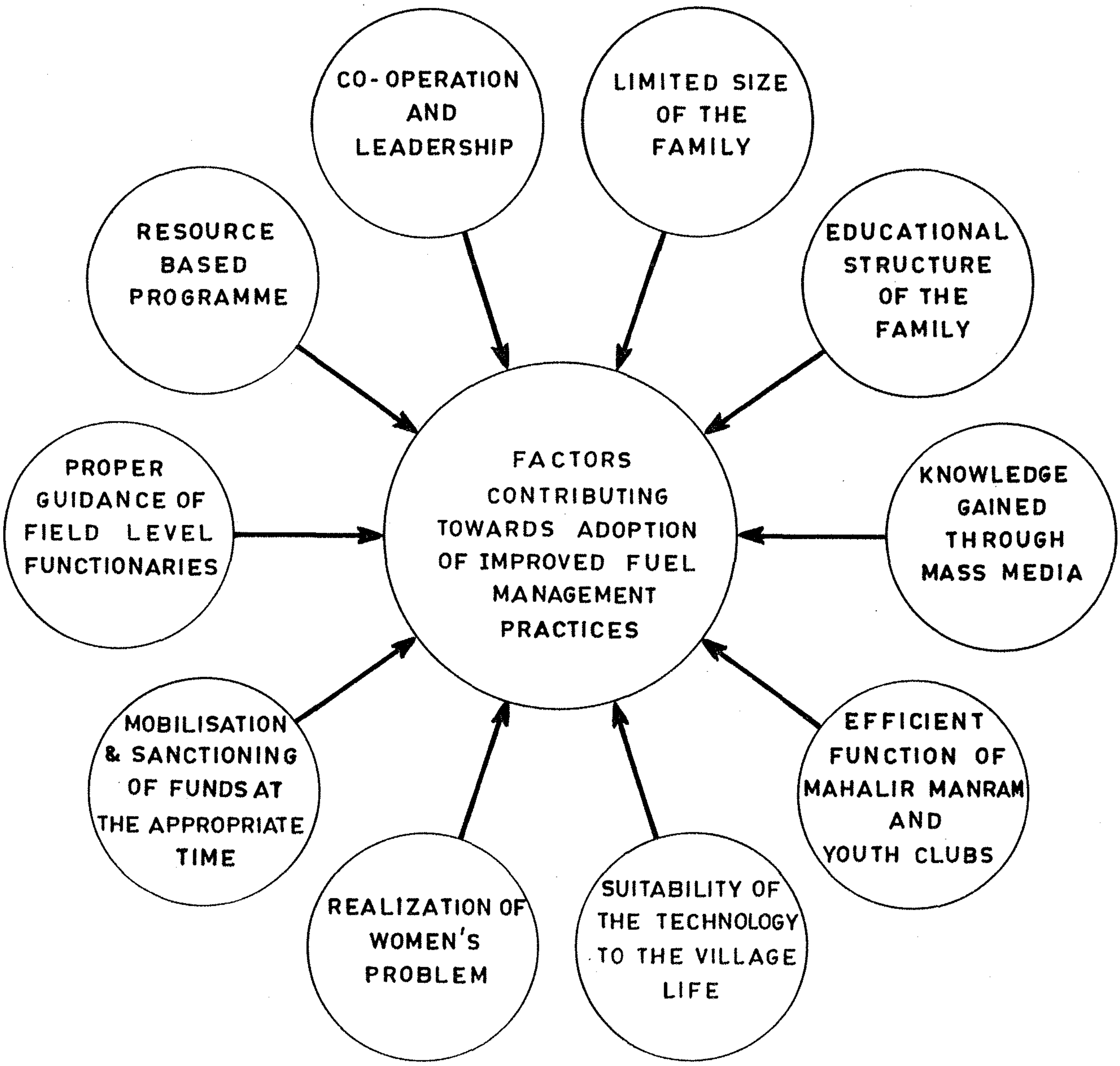
4. Though apparently solar cooking requires much more of time (50 per cent more than firewood) there is

the advantage of less attention for cooking required by the homemaker. The time thus saved could be used by the homemaker to complete the other household chores while the food is being cooked in the solar cooker.

5. The quantum of firewood that was saved was found to be 0.8 kg. per day which results in a saving of 160 kg. per family per annum if solar cooker is constantly used on all the sunny days.

This study has thus thrown light on the possibilities of saving fuelwood by introduction of improved fuel management practices in the rural households. The favourable factors associated with the adoption of any new innovation by the rural families as perceived by the investigator is shown in Figure 27. The following recommendations emerge from the study:

1. It is a happy augury that Government of India has initiated a number of sc¢hemes to combat the energy problem today. However, efforts should be taken to enable people to obtain the various benefits, through an integrated approach in the schemes of the Social Forestry Programmes, Department of Non Conventional Energy Sources (DNES), Khadi and Village Industries Commission(KVIC)and Department of Science and Technology (DST).



FACTORS CONTRIBUTING TOWARDS ADOPTION OF IMPROVED FUEL MANAGEMENT PRACTICES

FIGURE 27

2. The approach of the various agencies should be 'people oriented' and not merely 'target oriented'. To achieve this a strong motivational programme should be planned for the rural families through which they should be oriented to the scientific aspects of conserving fuel through the use of renewable sources of energy.

3. The failure of the Dome type Janata Biogas plants is mainly due to the faulty construction of untrained masons making an attempt to construct the 'dome type plants' which require special skill. Hence training of masons in the proper construction of 'Janata biogas plants', of potters in making smokeless chulahs, of artisans to fabricate solar cookers should form an integral part of the rural reconstruction efforts. The TRYSEM (Training Rural Youth for Self Employment) should be geared towards making smokeless chulahs, construction of biogas plants, fabrication, maintenance and repair of solar devices.

4. The scientific temper should be created to design the devices to suit the local needs.

5. Wider publicity should be given in a convincing manner through mass medias such as Radio, Television and Film shows that these improved fuel technologies help to conserve fuel and time, and at the same time leave a cleaner kitchen.

6. Introduction of these devices should be stressed in all the Rural Development Efforts in the country.

7. A close integration between research and extension activities in the country,must be maintained.

Agarwal, A. 1983 — 'Chipko - The Feminest Movement', Science for Villages, No.71/72, p.12.

Ahmed, A. 1978 — 'Fuel for the Future', The Illustrated weekly of India, Vol.XLIX, May, 14-20, p.39.

Ahsan, Q. 1985 — 'Use Energy With Care', Yojana, Vol.29, No.7, p.15.

Ahuja, D. and Gupta, C.N. 1968 — 'Study on the Efficiency of Chulas', Technical and Research Report, National Buildings Organisation, New Delhi, p.30.

Aiyasamy, P.K. and Kombairaju, S. 1980 — 'Economics of Gobar Gas Plant', Subject Matter Training.cum-Discussion Seminar on Biogas Production Technology, 28 Jan - 1st Feb, 1980, Tamil Nadu Agricultural University, Coimbatore, p.42.

Ajitha, A. 1980 — 'Utilisation of Garbage for Biogas Production', A thesis (unpublished) submitted to the University of Madras in Partial Fulfilment of the Requirements for the Degree of Master of Science.

Altekar, U.A. and Sampath, U.S. 1977 — 'Conservation of Metals and Energy Inputs Therefore', Energy Management, Vol.I, No.1, p.31.

Alvim, T.P. and Alvim, R. 1980 — 'Renewable Energy', Renewable Energy Review Journal, Vol.2, No.2, p.1.

Anand, Y.P. 1983 — 'Biogas Technology - For recycling, of Organic Wastes for Sanitation', Bioenergy - Re-news, February, 1983, p.21.

Arokiaswamy, N.S. 1978 — 'Need for New Energy Sources', Management of Energy for Rural Development, Energy Management, Vol.2, No.3, pp.3-6.

Avinashilingam, T.S. 1984	'Inagural Address', National Seminar on 'Utilisation of Solar Energy', Sri Ramakrishna Mission Vidyalaya, Coimbatore, 23-25 Jan, 1984.
Babu, S.C. 1983	'Animal Energy', Kissan World, Vol.X, No.9, pp.23-25.
Bachkheti, N.D. 1982	'Fuel Wood Crisis in India', Yojana, Vol.26, pp.87-90.
Bahuguna, S.L. 1972	'Chipko News', Science for Villages, Vol.V, No.5, p.5.
Batliwala, S. 1983	'Women and Cooking Energy', Economic and Political Weekly, Vol.XVIII, No.52 and 53, p.2227.
Batra, N.D. 1977	'Harnessing Sunshine for Rural Development', Yojana, Vol.XXI, No.11, p.18.
Behari, B. 1974	'Gandhian Approach to Energy Crisis', Khadigromodyog, Vol.XX, No.8, p.393.
Behrman, D. 1978	'Sunshine in the Kitchen', Invention Intelligence, Vol.13, No.6, p.222.
Behrman, D. 1979	'Solar Energy', Published by Routledge and Kegan Paul, London, p.5.
Bhaduria, P.B.S. 1980	'Role of Biogas Technology in Rural Development', Rural India, Vol.47, No.11 and 12, p.172.
Bhatt, S.M. and Reddy, S.B. 1982	'Biomass Energy for developing Countries', Changing Villages, Vol.4, No.4, p.23.
Bhattacharya, K.N. 1983	'Bio-Energy - The Energy for the Future', Vol.18, No.4, p.136.
Bhide, V.G. 1978	'Pathways to Solar Energy Utilisation, Invention Intelligence, Vol.9, No.7 and 8, p.255.

Bhushan, B. 1977 — 'The Case of Sun Basket Invention Intelligence, Vol.9, No.7 and 8, pp.255-260.

Biswas, D.K. 1976 — 'Biogas Plants for Environmental Improvement', Khadigromodyog, Vol. XXIII, No.1, pp.68-72.

Biswas, T.D. 1977 — 'Biogas Plants, Prospects and Limitations', Invention Intelligence, Vol.13, No.1, p.64.

Bose, S.C. 1981 — 'Development of Energy Sector', Yojana, Vol.XXV, No.120, p.4.

Bose, S.C. 1983 — 'A Report on the Promising Areas for Utilisation of Solar Cooker', Seminar on Efficient Utilisation on Cooking Energy, IAAS, New Delhi, August, 12, p.4.

Brinckworth, B.J. 1972 — 'Solar Energy for Man', John Wiley and Sons, New York, pp.90-92.

Broda, E. 1980 — 'Solar Energy in the Nineteen Eighties', Renewable Energy Review Journal, Vol.2, No.2.

Chandra, A. 1978 — 'Solar Energy Prospects and Future in India', Everyman's Science, Vol.XIII, No.4, pp.113-121.

Chittaranjan 1981 — 'Community Ownership of Biogas Plants', Yojana, Vol.XXVI, pp.16-21.

Chawla, O.P. 1975 — 'Gobar Gas - The Foresaken Innovation', Yojana, Vol.XVIII, p.54.

Clark, N. 1977 — 'Energy for Survival - The alternative to extinction', Allied Publishers, Bombay, pp.355-356.

Culham, W.B. 1975 — 'Energy from Water is Feasible', Journal of Environmental Health, Vol.37, No.6, pp.574-575.

Dahiya, R.P., Chand, A. and Dayal, M. 1982 — 'New Concept to use Biogas for Rural Sector', National Solar Energy Convention, Solar Energy Society of India, Indian Institute of Technology, New Delhi, 17-19 Dec, 1982, p.11.007.

Danam, B. 1981 — 'The Strategy of Social Forestry', Kurukshetra, Vol.XXIX, No.12, p.25.

Daniels, F. 1974 — 'Director use of the Sun's Energy', Yale University Press, New Hawan and London, pp.1-4.

Das, S.R. 1983 — 'Energy Scene in India', Yojana, Vol.27, No.19, pp.12-15.

Datta, R.L. 1974 — 'Solar Energy its Relevance to India', Invention Intelligence, Vol.9, No.7 and 8, pp.275-280.

Dayal, M. 1985 — 'India's Renewable Energy Scene', Science for Villages, No.87, p.7.

Department of Commerce. 1980 — 'Evaluation of Solar Cookers', Office of Technical Service, Vita Inc, p.8.

Department of Science and Technology. 1981 — 'Biogas Technology and Utilisation', a Status Report, Government of India, New Delhi, p.2.

Desai, V.R. 1983 — 'Fuel Wood in Indian Economy', Yojana, Vol.27, No.12, p.4.

De-Silva, E.J. 1979 — 'Biogas Generation Developments, Problems and Tasks - An overview in Bioconversion of Organic Residues in Rural Communities', Tokyo, The United Nations University, pp.84-98.

Devadas, R.P. 1980 — 'Sun the Prime Source of Energy', Home Science, Vol.18, No.10, pp.3-6.

Devadas, R.P. 1980 — 'Utilisation of Solar Energy for Household purposes', - Workshop on Utilisation and Conservation Natural Resources, India International Centre, New Delhi, p.1.

Devadas, R.P., Rajagopal, L.S. and Gnanambal. J. 1983 — 'Solar Energy for Household Purposes', National Seminar on Utilisation of Solar Energy, Sri Ramakrishna Mission Vidyalaya, Coimbatore, 23-25, Jan. 1983.

Devadas, R.P., Kamalanathan, G. and Rajagopal, L.S. 1983 — 'Smokeless Chulah - Design and Transfer', Changing Villages, Vol.5, No.5, p.402.

Devadas, R.P. 1985 — 'Educating and Motivating Rural Communities on Better Resource Management', Paper presented for the Indo-Swedish Symposium, 18-22, Feb, 1985, p.5.

Devanathan, 1979 — 'How Long Will the Sun Last', Junior Scientist, Vol.17, p.

Director, Publication Division, 1984 — Ministry of Information and Broadcasting, Government of India, pp.337-339.

Diwan, B. and Maini, S.D. 1981 — 'Solar Water Still', Home Science Vol.19, No.4, pp.19-20.

Diwan, B. 1983 — 'Solar Geyser', Home Science, Vol.21, No.1, p.12.

Eckholm, E.P. 1976 — 'The other Energy Crisis', Yojana, Vol.XX, No.12, p.15.

Eggeling, G., Guldager, R., Guldager, H., Sassa, L., Tretjen, C. and Werner, U. 1980 — 'Biogas Plants Building Instruction', German Agency for Technical Co-operation, Germany, p. 2-15.

Encyclopaedia of Energy. 1976 — McGraw Hill Book Company, pp.25-64.

ESCAP 1980 — 'Renewable Sources of Energy', Solar Energy - Vol.I, p.1,4 and 5.

Fenyves, E. 1983 — 'Better Environment by use of Natural Gas', Hindu, 1983.

Fuel Policy Committee. 1972 — Invention Intelligence, Jan-Feb., p.63.

Ganger, H.U. and Balasubramanya, R.H. 1983 — 'Improved Plant for Biogas Production Invention Intelligence, Vol.XVIII, No.12, p.503.

Ganguly, R.K. 1980 — 'Biogas Systems, Khadi Gramodyog', Vol.XXVIII, No.3, p.133.

Ganguly, R.K. 1980 — 'Biogas Technology for Rural Development, Performance and Prospects, Khadigramodyog, Vol.XXVII, No.3, pp.153-155.

Garg, H.P. 1977 — 'Solar Energy for Rural Development', Invention Intelligence, Vol.12, No.1 and 2, p.81.

Garg, R.B.L. 1981 — 'Biogas, Habinger of a New Way of Life', Kurukshetra, Vol.XXIX, No.23, pp.16-17.

Garg, H.P. and Bandyopadhyay, B. 1981 — 'Utilisation of Solar Energy for Space Heating', Invention Intelligence, Vol.16, No.7, p.317.

Garg, H.P. 1982 — 'Low Cost Built in Storage Solar Water Heater', Invention Intelligence, Vol.17, No.7, p.3,4,163, 173.

Gautam, S. 1974 — 'Energy Crisis, What we can do in India', Khadigramodyog, Vol.XX, No.8, pp.397-398.

Geetha, T. 1979	'Possibilities of Utilising Home Garden Waste for Production of Biogas and Organic Manure', A thesis (unpublished) submitted to the University of Madras in Partial Fulfilment for the Degree of Master of Science.
Gern, E. 1980	'Improved Cook Stoves in Upper Volta', German Agency for Technical Co-operation, Federal Republic of Germany, p.115.
Ghosh, S.N. 1977	'Meeting the Energy Needs of Rural India', Invention Intelligence, New Delhi, Vol.12, No.1, pp.63-67.
Ghose, T.K. 1980	'Methane from Integrated Biological Systems', Foods and Nutrition Bulletin. The United Nations University, Vol.2, No.3, pp.36-39.
Gnanambal, J. 1981	'Efficiency of Mobile Biogas Plant for Household Use', A thesis (unpublished) submitted to the University of Madras in Partial Fulfilment for the Degree of Master of Philosophy.
Gnanarathinam, J.L. 1982	'Biological Application of Solar Energy', Everyman's, Science, Vol.XVI, No.6.
Gondhalekar, G.H. 1975	'Economic Viability of Gobar Gas Plant', Commerce, Vol.31, No.3358, pp.31-33.
Gross, I.H. and Crandall, H.W. 1963	'Management for Modern Families', Appleton Crafts, U.S.A, p.1.
Grover, I. and Sharma, S. 1981	'Technology to the Aid of Rural Women', Kurukshetra, Vol.XXXIX., No.17, p.27.
Grover, P.D. 1982	'Concept and Performance, of Biomass Briquetted Fuel - 'Paru' Gas Stove', Changing Villages, Vol.5, No.5, p.294.

Gupta, C.L. 1974 — 'Solar Energy Devices - Indian Achievements', Invention Intelligence, Vol. 9, No.7 and 8, p.285.

Gupta, R. 1982 — 'Fire without Smoke', Changing Villages, Vol.4, No.3, p.1-4.

Gupta, S.C. 1977 — 'New Energy Resources for Rural India', The Agricultural Engineer, The Agricultural Engineering Society, Allahabad, Vol.19, pp.37-38.

Gupta, S.P. 1979 — 'Statistical Methods', Sultan Chand and Co., Delhi, pp.10, 24.

Gupta, V.K. 1978 — 'Solar Water Heaters and Rural Development', Changing Villages, Vol.2, p.9.

Gupta, M.L. and Vasudevan, P. 1983 — 'Need for Solar Energy', Invention Intelligence, Vol.18, No.7, pp.305-306.

Halchy, D.S. 1963 — 'The Coming Age of Solar Energy', Streling Publishing Ltd., pp.1-10, 231.

Hammond, A.L., Metz. W.D. and Maight, H. 1975 — 'Energy and Future', American Association for the Advancement of Science, Washington, pp.86.

Hammond, A. 1979 — 'Biomass Conversion - A Rediscovered Source of Fuels', Development Digest, Vol.XXII, No.3, pp.4-11.

Harigopal, Y. and Jonapi, K.V. 1980 — 'Technology for Villages', Khadigramodyog, Vol.XXVI, No.11, p.491-493.

Hazra, S. 1974 — 'Going for a Cowdung Gasplant', Home Science, Vol.12, No.1, p.8.

Hindu 1985 — 'Smokeless Wood Stoves Gain Wide Acceptance', 24th June, 1985.

Hoda, M.M. 1983 — 'Some Basic Concepts for Development of Appropriate Technology for Rural Areas', Changing Villages, Vol.5, No.1, pp.27-28.

Hogan, M.J. 1978 — 'Changing Energy Behaviour', Journal of Home Economics, Vol.10, p.24.

Indira Gandhi. 1981 — 'New and Renewable Sources of Energy', Science for Villages, Vol.V, No.1, p.3.

Indiravathi, K. 1968 — 'A Study of the Benefits Accruing from the use of Cowdung Slurry as manure in Vegetable Production as Compared with Compost and Farmyard Manure', A Thesis (unpublished) submitted to the University of Madras in Partial Fulfilment of the Requirements for the Degree of Master of Science.

Indian Association for the Advancement of Science. 1983 — 'Seminar on Efficient Utilisation of Cooking Energy, August, 1983, New Delhi.

Iyer, K. 1985 — 'Nuclear Nationalism and the Law', The Hindu, April, p.30.

Jain, B.C. 1980 — 'Solar Energy Systems from Baroda Unit',The Hindu, July 18th, p.21

Jayaraman, S. 1984 — 'Solar Energy for Agricultural Production', Nation Seminar on Utilisation of Solar Energy, January 23-25, Sri Ramakrishna Mission Vidyalaya, Coimbatore, p.1.

Jena, P.K. 1981 — 'Meeting the Energy Crisis', Yojana, Vol.25, No.17, p.17.

Johal, H.S. and Saini, S.P.S. 1980 — 'Installing Gobar Gas Plants - Stimulants, Barriers and Operational Difficulties', Changing Villages, Vol.II, No.2, p.11.

Johal, M.S. and Shukla, A.N. 1980 — 'Adoption of Gobargas Plants in Rural Areas', Khadigramodyog, Vol.XXVI, No.12, pp.546-548.

Joslin and Taylor, P.M. 1963 — 'Everyday Domestic Science and Hygiene', Third Edition, Macmillion and Co-Limited, London, pp.67-68.

Kalia, A.K. 1981 — 'Findings of the Drumless Biogas Plant', National Solar Energy Convention, Solar Energy Society of India, p.9.031.

Kamaraj, S. 1981 — 'Biogas Application', Training cum-Discussion Seminar on Biogas Production Technology, Tamil Nadu Agricultural University, Coimbatore, p.26.

Kamat, G.S. 1982 — 'Role of Social Forestry', Khadigramodyog, Vol.XXVIII, No.6, p.291.

Kanawade, L.R. and Ingle, N.J. 1984 — 'Energy Requirements its Alternate Source in Rural Areas', Rural India, Vol. 47, No. 24 Sep-Oct, 1984, pp.137-140.

Kandpal, T.C. and Mathur, S.S. 1982 — 'Solar Energy Experiments for School Level Students', National Solar Energy Convention, Solar Energy Society of India, Proceedings 17-19 December, 1982, Indian Institute of Technology, New Delhi, p.12.009.

Kapur, J.C. 1979 — 'Sun a Source of Energy for Rural India', Invention Intelligence, Vol.14, No.6, pp.216-217.

Kapur, K. 1982 — 'Energy for Rural Homes', Home Science, Vol.20, No.1, pp.6-11.

Kapur, N. 1980 — 'Fuels for Home', The Indian Journal of Home Science, Vol.XVIII, No.5, pp.6-8.

Kaskari, C.
1975

'Energy-Resources Demand and Conservation with Special Reference to India', Tata McGraw Hill Publishing Co., Ltd., pp.3,4,163,173.

Kaushik, D., Chandra, C. and Kaushik, S.C.
1983

'Drying of Agricultural Produce by indirect and mixed Solar Dryers', Invention Intelligence, Vol.18, No.1-2, p.

Khairoowala, Z. and Shankar, R.N.
1984

'Gobar Gas Technology', Kissan World, Vol.XI, No.2, p.45-48.

Khan, B.
1974

'Sunshine is the Fuel of the Future', Invention Intelligence, Vol.9, No. 7 and 8, p.240.

Khan, R.R.
1977

'More Foods from Domestic Wastes', Yojana, Vol.XXI, No.21, p.29.

Khandewal, K.C.
1984

'Biogas for Better Life', Changing Villages, Vol.6, No.4, p.274.

Khoshod, T.N.
1983

'Energy from Biomass', Indian Farming, Vol.XXXIII, No.3, p.10.

Kiely, C.
1979

'Solar Energy', A Do it Yourself Manual, Hamlyen London, p.5.

Kodli, M.C.
1985

'Energy Forest for Each Village', Yojana, Vol.29, No.5, p.9.

Kokry, P. and Muglane, S.S.
1980

'Is yours a Working Kitchen', Home Science, Vol.18, No.5, p.8.

Kothandaraman, C.D.
1980

'Design of Flat Plate Collector', Lecture delivered at the continuing Education Course on 'Solar Energy Developments and Design of Solar Energy Device', conducted by Coimbatore Local Centre of the Institution of Engineers, November 22, 1980.

Kreider, J.F. and Kreith, F. 1977 — 'Solar Heating and Cooling', Hemisphere Publishing Corporation, Washington, pp.3,5,10 and 12.

Kursunogalu, B. 1974 — 'Topics in Energy and Resources', Plenum Press, New York, p.25.

KVIC 1984 — 'Gobar Gas-Retrospect and Prospects', Directorate of Gobar Gas Scheme, Bombay, p.3.

KVIC 1984 — 'Gobar Gas - Why and How', Khadi and Village Industries Publication, New Delhi, pp.1-19.

Lakshmanan, RM. and Nallathambi, K. 1980 — 'Appropriate Energy Sources for Rural Areas' - Seminar on Energy Planning, Coimbatore Inst. of Tech., p.35.

Lavasa, A. 1985 — 'Biogas - Invention and Discovery', Kurukshetra, Vol.XXXIII, No.8, p.19.

Lokras, S.S. and Kumar, R. 1983 — 'Development of an Improved Three Pan Cook Stoves', Changing Villages, Special Issue, Vol.5, No.5.

* Malhotra, A.K. 1983 — 'Energy Scene in India', International Centre - Quarterly, Vol.10, No.3, p.283-284.

Mannan, K.D. 1981 — 'Cooking with Sun', Changing Villages, Vol.3, No.3, p.15.

Mannan, K.D. and Cheema, L.S. 1982 — 'Design Development and Performance Evaluation of a New Solar Cooker', National Solar Energy Convention, Dec 17-19, 1982, Solar Energy Society of India, Indian Institute of Technology, New Delhi, p.6.005.

Manorama Year Book. 1983 — Manorama Publishing House, pp.455-456.

* Majumdar, M. 1978 — 'Recycling waste', Yojana, Vol. XXII, No.13, p.9.

Masters, G.M. 1976 — 'Introduction to Environmental Science and Technology', John Wiley and Sons, Newyark, pp.255-269.

Mathews, M.W. 1979 — 'The Latest in Solar Energy', Span, Vol.XX, No.12, p.37.

Mathur, K.M. and Chandra, A. 1979 — 'Areas for accelerating Solar Energy Utilisation in India', Proceedings of the International Solar Energy Society Congress, 1979, Vol.3, New Delhi, p.2164.

Mathur, H.B., Gajendra Babu, M.K., Krishna Pal and Prasad, Y.N. 1982 — 'Biogas as an Alternate Fuel for Combustion Engines', National Solar Energy Convention Solar Energy Society of India, Indian Institute of Technology, New Delhi, p.6.00

Mathur, S.S., Garg, H.P., Dang, A. and Sharma, J.K. 1983 — 'Solar flux distribution from circular cylindrical concentrators', Solar Energy, Vol.30,

Mathur, S.S. 1983 — 'Energy options for Cooking', Seminar on Efficient Utilisation of an Cooking Energy', IAAS, New Delhi, August, 12, p.7.

Mayur, R. 1980 — 'Bio-Energy for Development in the Common Wealth Countries', Khadigramodyog, Vol.XXVII, No.3, p.164.

McVeigh, J.C. 1977 — 'Sun power - an Introduction to the Application of Solar Energy', Pergaman Press, New York, p.IX.

Meena, J.R. 1982 — 'Alternative Sources of Energy in Rural India', Yojana, Vol.26, pp.13-14.

Meena, J.R. 1984 — 'Solar Energy for Rural Areas', Yojana, Vol.28, No.8.

Mehdi, S.S. 1982 — 'Biogas Programme in India', Financing Agriculture, Vol.XIV, No.2-3, pp.4-17.

Metcalf, B. and Logvin, M. 1981	'Solar now', An Energy Primer and Guide to Low Cost Solar Cooking, Solar Tea, Solar Hot Water, p.16-23.
Miller, R.K. 1983	'Energy Conservation', Marketing Hand Book, p.174.
Ministry of Information and Broadcasting, 1984	'Twenty Point Programme', Government of India.
Moulik, T.K. 1977	'Promoting Biogas Technology in the Village Experiences in Gujarat', Presented at National Symposium on Biogas Technology and Usage held in New Delhi, Nov.29-30.
Mulmule, M.G. 1980	'Institutional Finance for Gobar Gas Scheme', Khadigramodyog, Vol.XXVI, No.9, p.395.
Murthy, N. 1982	'Offset - Food Paraboloidal Solar Stove', Invention Intelligence, Vol.17, No.1 and 2, pp.102-105.
Muthayya, B.C., Rao, T.R.S. and Murthy. 1976	'A Hand Book of Methadology of Research', Sri Ramakrishna Mission Vidyalaya, Coimbatore, p.161.
Muthu, N. 1981	'Corrosion in Gobar Gas Plant', Khadigramodyog, Vol.XXIV, No.11, p.23.
Muthu, S. and Madhavi, S. 1977	'Construction and Evaluation of a Nightsoil Gas Plant', Indian Journal of Home Science, Vol.11, No.2, p.38.
Myles, R.M. 1982	'Biogas Technology', AFPRO Publications, New Delhi, p.7.
Myles, Z. 1981	'Experiment in Cooking with Solar Energy', Invention Intelligence, Vol.16, No.12, pp.538-541.

Nadkarni, G.S. 1979 — 'Solar Cells', Everyman's Science, Indian Science Congress Association, Calcutta, Vol.XIII, No.6, p.175.

Nagar, S. 1976 — 'Gobar Gas Plants in Developing Rural Economy', Khadigramodyog, Vol.XXII, No.6, pp.272-276.

Nair, R. 1984 — 'Fabrication of study of Solar Still', National Seminar on Utilisation of Solar Energy, January 23-25, Sri Ramakrishna Mission Vidyalaya, Coimbatore, p.2.

Narayandas, K. 1980 — 'Sun', Kalaikadir, Vol.32, No.4, pp.1-5.

Ng.Y.B. and Loung, C.T. 1982 — 'Solar Technology in China' - Review Sun World, Vol. – No.4, p.114.

N.R.D.C. 1985 — 'N.R.D.C - Takes Technology to Villages', National Research Development Corporation of India, New Delhi, pp.5-41.

Oblisami, G. 1980 — 'Interaction of Environmental Factors in Relation to Biogas Production', Training-cum-Discussion Seminar on Biogas Production Technology, Tamilnadu Agricultural University, Coimbatore, p.67.

Odum, M.T. and Odum, E.C. 1971 — 'Energy Basis for Man and Nature', New York McGraw Hill, Inc. pp.2527.

Padmanabhan, V. 1978 — 'What Constitute Over all Management', Expert Group Meeting on Biogas Development, Bangkok, June, 1978, pp.2-7.

Pal, P.C. and Kalra, R. 1981 — 'Low Cost Clay Energy Appliances for Rural Areas in India - A Clay Biogas Plant and a Clay Solar Cooked', National Solar Energy Convention, 1981, Proceedings, January, 22-24, p.9.031.

Palaniappan, C. 1984 — 'Solar Drying of Spices and Food Materials in a Batch Drying', National Seminar on Utilisation of Solar Energy, Sri Ramakrishna Mission Vidyalaya, Coimbatore, 23-25 January, 1984.

Palanisamy, P.T. 1981 — 'Design of Biogas Ovens', Training-cum-Discussion Seminar on Biogas Production Technology, Tamil Nadu Agricultural University, Coimbatore, p.28.

Pandey, A.C. 1982 — 'Description of Janata Biogas Plant', The Indian Journal of Home Science, Vol.II, No.4, p.1.

Pandit, K.K. 1983 — 'Fuel and Cooking Systems', Meeting to Review the Progress of Projects funded under the Scheme, 'Science and Technology' for Women, New Delhi.

Panickar, T.B., Ramalingam, R. and Salam, A. 1985 — 'Horizontal Type Biogas Plant', Hindu.

Pant, K.C. 1983 — 'Key Note Address - Workshop on Cook Stoves - Fire wood Burning Designing and Transfer', Changing Villages, Vol.5, No.5, p.267.

Parikh, E. 1978 — 'Energy', The Macmillian Company of India Limited, Madras, pp.130-131.

Parikh, K. 1976 — 'Second India Studies - Energy' The Macmillian Company of India, New Delhi, p.3.

Parikh, M. and Kakalia, M. 1978 — 'Garbage Gas Plant', Khadigramodyog, Vol.24, No.6, pp.310-318.

Parikh, M. and Parikh, R. 1984 — 'Box-Type Solar Cooker', Pamphlet, Surche Chhapshala, Bardoli.

Parmora, D.P. 1983 — 'Biogas Plant an aid to Agriculture', Indian Farmer's Digest, Vol.XVI, No.10, p.13-15.

Patel, I. 1983 — 'Cook-Stove-Firewood Burning, Designing and Transfer', Changing Villages, Vol.5, No.5, pp.354-367.

Patel, A.R. 1977 — 'Gobar - A Potential Source of Energy', Yojana, Vol.XXI, No.12, pp.25-27.

Patol, H. 1980 — 'Biogas Plants and Rural Development', Khadigramodyog, Vol.XXVI, No.5, p.6.

Patel, P.R. 1977 — 'Solar Energy Prospects and Problems', Yojana, Vol.XXI, No.5, p.29.

Patel, S.J. and Dhangade, M.P. 1984 — 'Economics of Gobar Gas Plants in Ahmednagar', Yojana, Vol.XXX, No.4, p.195.

Patel, A.R. and Pandya, P.B. 1979 — 'Recycling of Agricultural Wastes', Khadigramodyog, Vol.XXV, No.4, p.210.

Patel, A.R. and Patel U. 1985 — 'Financing for Gobar Gas Plant', an evaluation, Khadigramodyog, Vol.XXXI, No.6, p.262.

Paul, J.C. 1977 — 'Solar Heating and Cooling', Recent Advance, Noges Data Corporation, U.S.A.,p.1.

Paul, S. 1983 — 'Wood Energy Perspectives', Changing Villages, Vol.5, No.5, pp.393 and 394.

Perumal, S.P. 1983 — 'Smokeless Chulahs', Technology for Rural Women, National Seminar on Rural Development, Tamil Nadu Agricultural University, Coimbatore, p.3.

Peter, S.D. and Alikhan, W.M. 1984 — 'Major Energy Sources of our World', Kissan World, Vol.II, No.3, p.44.

Phadnis, L. 1983 — 'Smokeless Chulah', Home Science, Vol.21, No.8, p.7.

Pichai, R. 1984 — 'Need for Solar Energy', National Seminar on Utilisation of Solar Energy, 23-25, Jan.1984, Sri Ramakrishna Mission Vidyalaya, Coimbatore.

Prakash, U. 1978 — 'Solar Energy for Rural India', Kurukshetra, Vol.XXV, No.5, p.10.

Prasad, R. 1984 — 'Improved Chulahs - The Basis and Some Attempts to Scientific Designs', Changing Villages, Vol.6, No.6, pp.458, 459 and 463.

Prasad, R. and Mandal, A. 1983 — 'Designing a Scientific Wood Burning Cook Stove', Changing Villages, Vol.5, No.5, p.330.

Raghuraman, V. 1983 — 'Energy - Development Quality of Life', Energy Management, Vol.7, No.3, p.178.

Ragunath, S. 1974 — 'Going for a Cowdung Gas Plant', The Journal of Home Science, Vol.VIII, No.2, pp.8-12.

Rai, G.D. 1980 — 'Solar Energy Utilisation', Khanna Publishers, Delhi, pp.1-3.

Rajadhyaksha, V.G. 1980 — 'Solar Energy - Answer to Energy Crisis', Yojana, Vol.XXIV, No.4, p.5.

Rajani Devi, P. 1979 — 'Utilising Garbage for Biogas Production', Thesis (unpublished) submitted to the University of Madras in Partial Fulfilment of the Requirements for the Degree of Master of Science.

Rajasekaran, P. 1980 — 'Microbial Action in Biodigestion of Farm Wastes for Energy', Training-cum-Discussion Seminar on Biogas Production Technology, Tamil Nadu Agricultural University, p.6.

Rajiva, M. and Vats, R.K. 1979 — 'Solar oven as a Substitute to Solar Cooker', Invention Intelligence, Vol.14, No.11, pp.442-443.

Rajiva Gandhi. 1985 — 'Prime Minister's Broadcast to the Nation', Commerce, January, 5, 1985, Vol.150, No.3843, p.118.

Rajput, R.K. 1984 — 'A Treatise on Janatha Model Gobar Gas Plant, 'Changing Villages', Vol.III, No.4, p.241-242.

Raju, S.P. 1957 — 'Smokeless Kitchens for the Millions', The Christian Literature Society India, pp.7-12.

Ramachandran, A. 1976 — 'Research Development and Energy with Renewable Energy Resources', Science and Culture, Vol.42, No.8, p.384.

Ramachandran, J. 1980 — 'Energy', Yojana, Vol.XXIV, No.14-15, p.57.

Ramalingam, K.K. 1978 — 'Future Opportunities in Solar Energy', The Hindu, September 18, p.3.

Ramaraju, A.R. 1978 — 'Solar Devices', Junior Scientist, Vol.16, No.13, pp.56-58.

Ramaraju, A.R. 1978 — 'Solar Devices', Junior Scientist, Vol.16, No.3, pp.56-60.

Ramaraju, A.R. 1978 — 'Solar Energy and its Uses', Yojana, Vol.16, No.2, p.32.

Rangaswamy, P. 1976 — 'Tools for Collecting Data Interview', A Hand Book of Methodology of Research, Sri Ramakrishna Mission Vidyalaya, Coimbatore, p.94.

Rao, K.V. 1983 — 'Planning for Our Energy needs in 2000 A.D', Yojana, Vol.27, No.22, pp.9-11.

Rao, M.V.R. 1982 — 'Gobar Gas Scheme in Andhra Pradesh - a Critical Study', Khadigramodyog, Vol.XXIX, No.2, p.109.

Rao, N.K. 1984 — 'Energy Strategy for India', Khadigramodyog, Vol.XXX, No.8, pp.325-329.

Rao, P.A. 1985 — 'Design Deficiencies in Solar Cookers', Hindu - 14th August, 1985.

Rao, S. and Vaidyeswaran, R. 1981 — 'Why not use Charcoal', Science Today, p.56, October.

Rathnam, C.V.S. 1974 — 'Priorities in Solar Energy Research', Invention Intelligences, Vol.9, No.7 and 8, pp.237-238.

Ravindra, C.S.V 1981 — 'The Sun Basket', Science for Villages, Vol.5, No.3, p.5.

Reddy, C.P. 1981 — 'Energy from Gobar Gas', Kurukshetra, Vol.XXI, No.5, pp.21-23.

Rele, S.J. 1978 — 'Solar Energy for Rural India', Kissan World, Vol.5, No.8, pp.21-22

Relwani, L.L. 1984 — 'Biomass Energy Assessment', Changing Villages - Special issue, Vol.6, No.5, p.338.

RERIC. News 1983 — 'Improving Stove Programme', Vol.7, No.2, p.3.

Rolz, C., Merchu, J.P., Decabrera, S., Deleon, R. and Calzade, F. 1979 — 'Strategies for Developing Small Scale Fermentation Processes in Developing Countries in Bio Conversion of Organic Residues for Rural Communities', Tokyo, The United Nations University, pp.36-40.

Roy, A.G. 1982 — 'They show the way ....' Kurukshetra, Vol.XXXI, No.6, pp.21-22.

Salariya, K.S. 1983 — 'Energy Conservation in Domestic Combustion', Tata Energy Research Institute, Bombay, 1983, p.VII.

Salariya, K.S. and Jindal, S.L. 1983 — 'Smokeless Rural Cooking Appliances', Changing Villages, Vol.5, No.5, p.304.

Salaiya, C.S. and Singh, D. 1982 — 'Energy Technologies for the Village', Invention Intelligence, Vol.17, No.12, p.497.

Sankaranarayanan, M., Vijayaraghavan, N.C. and Swaminathan, K.R. 1983 — 'Solar Energy - Perspections and Potentials for Rural Development', National Seminar on Energy for Rural Development, November 10-11, 1983, Tamil Nadu Agricultural University, Coimbatore, pp.90-98.

Sapru, S. 1983 — 'Total Energy System' - Hope for Village, Hindu.

Sathe, V. 1982 — 'Energy Conservation and use of New Source', Yojana, Vol. 26, June.

Sathianathan, K. 1975 — 'Biogas Achievements and Challenges', Association of Voluntary Agencies' for Rural Development, New Delhi, pp.35-38.

Saxena, V.B. 1975 — 'Gobar Gas Plant - How and Why', Rural India, Vol.38, No.9.

Science and Technology for Women, 1982 — 'A Compendium of Technologies compiled by Centre of Science for Villages, Department of Science and Technology, New Delhi.

Science for Villages Editor, 1983 — 'Biogas Technology', Vol.VI, No.69, p.2.

Selvi, R. 1980 — 'Utilisation of Agricultural Waste for Biogas Production', A thesis (unpublished) submitted to the University of Madras in Partial Fulfilment of the Requirements for the Degree of Master of Science.

Sen, B. 1979 — 'Energy Crisis - A Blessing in Disguise', Yojana, Vol.23, pp.5-6.

Sethna, H.N. 1977 — 'Survey Conservation and Utilisation of Resources', Science and Culture, Vol.43, No.12, p.52.

Shah, H.C. 1984 — 'Biogas Development in Gujarat State', Changing Villages, Vol.6, No.4, p.

Shah, S.A. 1974 — 'Contribution of Forest in Garibi Hatao Programme', Khadigramodyog, Vol.XX, No.5, p.45.

Shah, K.S. and George, V.C. 1982 — 'Energy Plantation for Wood Burning and Wood Gasification', Solar Energy Convention, Solar Energy Society of India , Indian Institute of Technology, New Delhi, p.11.001.

Shanmugam, N.V., Selvam, M., Shenai, B.A., Srinivasan, K.N.and John, S. 1984 — 'Solar Cooker Using Coatings for enhanced Solar Thermal Energy Conversion', National Solar Energy Convention, Jan.22-24, New Delhi.

Sharin, M. 1982 — 'My Experience is promoting Improved Chulah', Science for Villages, No.61, pp.9-10.

Sharma, K. 1983 — 'Let women decide for Themselves', Indian Express Magazine, Jan.27.

Sharma, M.P. 1984 — 'Solar Cookers help in saving fuel', Energy Management, Vol.8, No.2, p.131.

Sharma, P.S. 1984 — 'Conserving Energy for Cooking', Uplift, Vol.XI, No.4, p.26.

Sharma, U.P. 1976 — 'Energy from Water', Proceedings of the Summer Institute on Waste Management by Recycling Part I, Bombay National Dairy Research Institute, pp.176-184.

Sharma, U.P. 1980 — 'Biogas Systems', Editorial, Khadigramodyog, Vol.XXVII, No.3, p.195.

Simon, A.L. 1975 — 'Energy Resources', Pergamon Press Inc, New York, p.IX.

Sing, A. 1980 — 'Unified Solar Energy Conversion Plant', Invention Intelligence, Vol.15, No.3, p.107.

Singh, J.B. 1981 — 'Biogas Plants - Time for a Progmatic approach', Yojana, Vol.XXV, No.11, pp.27-29.

Sivanandam, C. 1974 — 'Utilisation of Solar Energy', Junior Scientist, Vol.II, No.22.

Sivanappan, R. and Subramaniam, V. 1981 — 'Task force Report on Biogas Technology', Tamil Nadu Agricultural University, Coimbatore, pp.3.

Soni, M.C. and Patel, A. 1984 — 'Profitability of Gobar Gas Plants', Rural India, Vol.47, No.1-2, p.19.

Spears, J.S. 1978 — 'Wood as an Energy Source, The Situation in the Developing World', Annual Meeting of the American Forestry Association.

Srinivasan, H.R. 1980 — 'Elements of Biogas Technology', Khadigramodyog, Vol.XXVII, No.3, p.176.

Srivastava, B.P. 1984 — 'Magan Choola - A Smoke Free Cooking Oven', Khadigramodyog, Vol.XXX, No.4, p.190.

Subramanian, T.V. 1980 — 'Gobar Gas Plant: Optimization and Economic Feasibility', Khadigramodyog, Vol.XXVI, No.10, p.450.

Subramanya, S.K. and Ganesh, S. 1974 — 'Biogas Technology Performance and Prospects in India', National Committee on Technology, Government of India, p.76.

Subramanyan, V. 1986 — 'Alternate Energy for Rural Homes', Hindu, Feb.14, p.17.

Sodha, M.S. and Prasad, R. 1981 — 'Efficient Chulahs, Households wood cook stoves', Science for Villages, No.39, p.9.

Sukhatme, S.P. 1984 — 'Solar Energy - Principles of Thermal Collection and Storage', Tata McGraw Hill Publishing Company, New Delhi.

Sundaresan, D. 1984 — 'Canara Bank strategies and experiences in Financing Biogas Plants', Khadigramodyog, Vol.XXX, No.8, p.336.

Suryanarayana, C.V. 1978 — 'The Sun for every one', Science Reporter, Vol.15, No.1.

Swaminathan, K.R. 1980 — 'Biogas Technology Research at Tamil Nadu Agricultural University', Report of Biogas Production Technology, T.N.A.U. Coimbatore, pp.1-5.

SWRC, 1983 — 'Progress of the Improved Chulah Project under DST's AICP - Fuel and Cooking Aspects', Indian Institute of Technology, Delhi, April, 29-30.

Talwar, S.P. 1979 — 'The Alternate Fuel', Yojana, Vol. XXIII, No.8, p.32.

Tam, D.M. and Thanh, N.C. 1983 — 'Biogas Technology in Asia - the prospectives', Renewable Energy Review Journal, Vol.5, No.1, pp.1-10.

Tarcici, A. 1974 — 'Sun Cooked Lunches', Invention Intelligence, Vol.9, No.7 and 8, p.273.

Tarekar, M.G. and Zadgaonkar, A.S. 1979 — 'Solar-MHD-Desalinator', Proceedings of International Solar Energy Society Congress, New Delhi, Vol.3, p.2156.

Tata Energy Research Institute. 1982 — Vol.I, No.9, Tatar Press Limited, p.11.

Tata Energy Research Institute. 1983 — 'Cooking with chulahs', A survey in Bhavanagar Area, pp.1-25.

~~Tena, P.K. 1981 — 'Meeting the Energy Crisis', Yojana, Vol.XXV, No.17, p.17.~~

The Encyclopaedia Britannica of Energy 1976. 'Solar Energy'- Encyclopaedia Britannica, U.S.A., Vol.IX, p.330.

Thiruvengadam, T. and Ramamoorthy, T.S. 1983 — 'Information on Rural Solar Cookers', National Seminar on Energy for Rural Development, Tamil Nadu Agricultural University, Coimbatore, pp.106-124.

Thiyagarajan, P.R. 1980 — 'Solar insolation calculation', Annual paper meeting and continuing education on Solar Energy Developments and Design of Solar Energy Devices, Nov.21-22, PSG College of Technology, Coimbatore.

Til, J.V. 1982 — 'Living with Energy Short Fall', Published by Westview Press, Inc, Boulder pp.21,68.

Thomas, A.M. 1980 — 'Biogas Technology, and K.V.I.C', Khadigramodyog, Vol.XXVII, No.3, pp.149-158.

Tuve, G.L. 1976 — 'Energy Environmental Population and Food', A Wiley Inter Science Publication, John Wiley and Sons, New York, pp.76-82.

Tyagi, P.D. 1984 — 'Fuel Wood from Waste Land', Khadigramodyog, Vol.XXX, No.10, p.418.

Umesh, B.V. and Seshadri, C.V. 1981 — 'Jwala - Improved Biogas Plant', Invention Intelligence, pp.64-68. Vol.19, No.2.

Vaithilingam, 1984 — 'Instruction for the use Box-Type Solar Cookers in Homes', National Seminar on Utilisation of Solar Energy, 23-25 Jan, 1984, Sri Ramakrishna Mission Vidyalaya, Coimbatore.

Varalakshmi, S.R. and Muthu, S. 1977 — 'Extent of use of Cowdung Gas as household fuel in Coimbatore District', Indian Journal of Home Science, Vol.II, No.4, p.83.

Vasudevan, A. 1982 — 'Solar Energy', Junior Scientist, Vol.20, No.3, pp.67-69.

Vasudevan, P. and Santosh 1983 — 'Safeguarding consumer interest problems of rural sector', Seminar on efficient utilisation on cooking energy, IAAS, New Delhi, Aug.12, p.2.

Vedant, C.S. 1985 — 'A Policy prospective for Forestry', Yojana, Vol.29, No.5, p.9.

Venkatappa _et.al_ 1981 — 'Perception of non adopters about existing and new biogas plants', Changing Villages, Vol.XXVII, No.8, p.418,420-425.

Venkatasubramaniam, K.V. 1983 — 'Cooking with Solar Energy', Invention Intelligence, Vol.18, No.7, pp.280-282.

Venkatesan, D. 1978 — 'The Sun and the Earth's Climate', Science Today, Vol.12, No.12, p.13.

Venkateswaran, K. 1979 — 'Harnessing the Sun for Rural Development', Khadigramodyog, Vol.XXV, No.4, p.197.

Verma, O.S. 1979 — 'Gobar gas plant Installers Scientific Parsimoni', Khadigramodyog, Vol.XXV, No.8, pp.365-368.

Veziroglu, T.N. 1976 — 'Solar Cooking and Heating - Architectural, Engineering and Legal Aspects', Proceedings of the Solar Cooling and Heating Forum, Vol.III, Dec.13-15.

Vidyarthi, V. 1983 — 'Technologies for Rural Women', Appropriate Technology Development Association, Lucknow.

Vijayaraghavan, N.C. 1984 — 'Agricultural Application of Solar Energy', National Seminar on Utilisation of Solar Energy, 23-25, Jan, 1984, Sri Ramakrishna Mission Vidyalaya, Coimbatore.

Vimal, O.P.
1975

'Rural Prosperity through Waste Utilisation', Khadigramodyog, Vol.XXI, No.6, pp.276-279.

Vilkinson, K. and Bhandarkar, M.
1982

'Methodology and Techniques in Social Research', Himalaya Publishing House, Bombay, pp.264, 270.

Warner, U. and Chawla, O.P.
1981

'Energy through Gobargas for small farmers', Khadigramodyog, Vol.XXIII, No.12, p.546.

Wascheck, B. and Carmen, W.
1978

'Your Guide to good shelter', Reston Publishing Company, Newyork, p.75-78.

Wilson, C.L.
1977

'Energy Global Prospects 1985-2000', Report on the Workshop on Alternative Energy Strategies, McGraw Hill Book Company, Newyork, p.40.

APPENDICES

APPENDIX I

TOTAL SOLAR RADIATION IN CALORIES/cm^2/DAY

	Station	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
1	Trivandrum	653	692	749	775	766	749	758	767	752	710	645	628	721
2	Bangalore	584	650	690	706	703	692	746	704	695	649	631	562	668
3	Madras	699	709	747	764	765	750	749	756	750	709	680	605	720
4	Bombay	553	651	736	789	792	791	795	793	638	661	573	542	701
5	Poona	554	630	734	756	762	741	755	736	698	632	562	533	675
6	Ahmedabad	532	618	709	809	811	814	807	785	746	640	558	567	695
7	Jodhpur	486	574	684	792	810	835	805	770	708	597	507	446	668
8	Allahabad	512	593	699	789	805	821	805	761	693	624	481	421	655
9	Delhi	451	551	662	778	803	827	805	761	693	624	481	421	655
10	Jallandar	430	553	657	774	849	844	812	776	669	617	446	403	651

NOTE: The radiation values in the above table are cloudless stay condition

SOURCE: National Committee on Science and Technology, Solar Energy, Promise and challenge.

APPENDIX II

QUESTIONNAIRE USED TO ELICIT INFORMATION REGARDING FUEL MANAGEMENT PRACTICES

I. General Details:

Name of the Village :

Panchayat :

Panchayat Union :

District :

Name of the Interviewee :

Address :

Name of the head of the household :

Relationship to the interviewee :

Type of family : Nuclear Joint

Caste :

Mother tongue :

Family occupation :

Own house or rented :

Area of the house :

Area available in the front yard :

Area available in the court yard :

Location of the household :

2. Family details:

S.No.	Name of the member	Relation to the head of family	Age	Educational status	Main Occupation	Subsidiary occupation	Income per month

3. Family income and expenditure:

a) Income from (a) Major Source : Rs.

(b) Land : Rs.

(c) Subsidiary occupation : Rs.

(d) Others if any : Rs.

Total : Rs.

b) Expenditure (per month):

Food : Rs.

Clothing : Rs.

Fuel : Rs.

Housing : Rs.

Education : Rs.

Health : Rs.

Transport : Rs.

Social Expenses : Rs.

Personal : Rs.

II. Fuel management:

1. Information on fuel:

Fuel used and procurement of fuel:

S.No.	Type of fuel used	Source		
		Own farm and house	Neigh-bourhood	Pur-chased
1	Fire wood			
2	Barks and twigs			
3	Crop waste (specify)			
4	Coconut shells and fibres			
5	Dung cake			
6	Charcoal			
7	Kerosene			
8	Biogas			
9	Any other			

2. Storage of fuel:

Fuel	Place of storage	Method of storage		Problems if any in storage
		Rainy season	Other season	

3. Person responsible for collection of fuel:

Fuel	Person collecting	Age in years	Place of collecting (distance in km)	Time taken in collecting	Problems if any

4(a) Quantity of fuel used per day

S.No.	Items prepared	Quantity of fuel used	Amount spent per day on fuel Rs.	Problems in using fuel

(b) Other purposes for which fuel used:

5. Problems in using fuel:

Fuel	Problems in using fuel	Methods adopted to overcome

6. Type of chulah stove used:

Type of chulah/ Stove	Place of insta-llation Direction facing	Working level	Problems

7. Condition of the kitchen:

8. <u>Awareness of other fuels/stoves</u>:

a) <u>Smokeless Chulah</u>:

i) Have you heard about smokeless chulah? Yes No

ii) If 'Yes' source of information:

iii) Would you like to install a smokeless Chulah in your kitchen? Yes No

b) Solar Energy:

i) How do you generally utilise solar energy in daily life?

ii) Have you seen a solar cooker? Yes No

iii) If 'Yes', source of information:

iv) Would you like to use solar cooker for cooking purposes?

c) Cowdung gas plant:

i) Do you have cows, buffaloes in your house? Yes No

ii) If 'Yes', give the number of animals possessed by you

iii) How do you utilise the cowdung now?

iv) Are you interested in constructing a gas plant for your use?

v) If 'Yes', what type of help you require from us?

APPENDIX III

PROCEDURE FOR CALCULATING THE THERMAL EFFICIENCY OF SMOKELESS CHULAH

The thermal efficiency is calculated using the formula,

$$\text{Efficiency} = \frac{\text{Total heat used in raising the temperature of water}}{\text{Total heat potential of the firewood burnt}}$$

$$= \frac{(w_1 s + w_2 - w_1)\ (t_2 - t_1)}{[c.v.\ (w_3 - w_4)]} \times 100 \text{ per cent}$$

where

w_1	=	Weight of the utensil and the lid	=	200 grams.
w_2	=	Weight of the utensil, lid and water	=	1200 grams.
s	=	Specific heat of aluminium	=	0.2
t_1	=	Initial temperature of water	=	27°C.
t_2	=	Final temperature of water	=	98°C.
c.v.	=	Effective heat	=	814 kcals.
w_3	=	Initial weight of the wood	=	1000 grams.
w_4	=	Weight of the remaining wood	=	637 grams.
$(w_3 - w_4)$	=	Weight of the fuel consumed	=	363 grams.

Substituting these values,

$$\text{Efficiency} = \frac{[200 \times 0.2 + 1200 - 200]\ [98 - 27]}{814 \times 363} \times 100 \text{ per cent}$$

$$= 25 \text{ per cent.}$$

APPENDIX IV

TIME TAKEN TO COOK THE SELECTED ITEMS IN THE SOLAR COOKERS

Item	Trials	Solar intensity $cal/cm^2/day$	Wind velocity	Sunshine Hrs.	Time taken in minutes: Box type	Reflector oven	Solar basket
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rice (80 grams)	1	250.4	3.5	10.4	50	60	45
	2	235.8	5.1	9.5	60	75	50
	3	241.6	3.8	9.5	55	50	45
Mean					55	61.6	45
Green gram dhal	1	204.8	3.8	7.0	60	85	50
	2	208.0	2.9	6.5	60	65	45
	3	267.2	2.6	10.9	50	55	40
Mean					56.6	68.3	45
Whole green gram dhal	1	260.0	3.5	10.6	60	90	50
	2	261.6	2.9	10.9	60	90	50
	3	252.8	3.2	11.0	95	105	60
Mean					71.6	95	53.3
Red gram dhal	1	265.6	3.2	11.0	90	105	85
	2	267.2	3.2	11.2	90	105	80
	3	272.8	3.8	10.8	65	100	75
Mean					88.3	103.3	80
Potatos	1	259.2	7.4	10.3	75	105	75
	2	262.4	6.1	10.4	60	90	60
	3	260.8	5.1	11.5	75	90	65
Mean					70	95	66.6
Carrot	1	252.2	2.6	10.7	80	90	75
	2	258.4	3.5	10.6	50	90	45
	3	260.8	3.5	10.9	45	60	45
Mean					58.3	70	55
Beans	1	341.2	2.9	10.9	30	50	25
	2	126.4	6.1	11.4	55	85	30
	3	259.2	7.4	6.1	40	60	35
Mean					41.6	65	36.6

APPENDIX Va

வளமான வாழ்விற்கு புகையில்லா அடுப்பு !

சமையலறையில் கரிப்பிடிக்காமல் தடுக்கிறது

எரி பொருள் மிச்சப்படுத்துகிறது

விறகுக்கு ஆகும் செலவைக் குறைக்கிறது.

சமைக்கும் நேரத்தைக் குறைக்கிறது.

வீட்டில் புகை வராமல் தடுக்கிறது.

பாத்திரங்களில் கரிப்பிடிக்காமல் இருக்க உதவுகிறது

பாத்திரங்களை தேய்க்கும் நேரத்தை மிச்சப்படுத்துகிறது.

வீட்டுத் தலைவியின் ஓய்வு நேரத்தை அதிகரிக்கச் செய்கிறது

கண் எரிச்சலைத் தவிர்க்கிறது

ஆரோக்கிய வாழ்வை அதிகரிக்கிறது.

APPENDIX V b

புகையில்லா அடுப்பை உபயோகியுங்கள்!

APPENDIX Vc

சூரிய ஒளி அடுப்பை பயன்படுத்துங்கள் !

எரி பொருள் மிச்சம்

பாத்திரங்கள் சுத்தம்

உணவின் ருசி அதிகம்

புகைத் தொல்லை இல்லை

சமைத்தல் எளிது

சமைக்கும் நேரம் மிச்சம்

ஆரோக்கியம் கிட்டும்

APPENDIX VI

EVALUATION SHEET USED FOR SMOKELESS CHULAH

I. Name of the Village :

Name of the head of the family :

Occupation :

Number of members :

Adults :

Children :

Type of family :

Education of the homemaker :

Education of the head of the family :

Total income of the family :

II. Details regarding Installation:

1. Place of installation :
2. Area needed for installation :
3. Direction faced :

   Reasons :
4. Placement of smoke outlet pipe :
5. Level of the chulah: High Low
6. Area occupied by the chulah:

   Height :

   Width :

   Length :

7. Materials required for installation:

Materials	Quantity	Cost

8. Number of labourers and time involved for installation :

9. Labour charges involved in the installation :

10. Any specific day selected for the installation :

    Reasons :

11. Person supervised the installation :

III. Details about using the Chulah:

1. How many days were allowed for the settlement of the chulah?

2. Mention the preparations which are made using the first pot seat.

   Items prepared　　Quantity prepared

3. Mention the preparations which are made by using the second pot seat:

Items prepared	Quantity prepared

IV. Use of Dampers.

V. Benefits and suggestion:

1. What are the reaction of the homemaker after using chulah?

2. Suggestion for the improvement of the chulah design:

Size :

Shape :

Chimney :

Diameter of the first pot seat :

Diameter of the second pot seat :

Ash plate :

Sloping between the 1st and 2nd pot seat :

3. Advantages of the smokeless chulah over the ordinary chulah:

VI. <u>Maintenance</u>:

1. How do you maintain the chulah?

2. What type of help and assistance you need in the programme?

3. Problems faced in using the chulah:

VII. What is your opinion about the introduction of smokeless chulah in the rural area?

APPENDIX VII

SCHEDULE TO ELICIT INFORMATICNS REGARDING THE PERFORMANCE OF JANATA BIOGAS PLANTS CONSTRUCTED IN SELECTED HOUSEHOLDS

1. Name of the interviewee :

   Address :

2. Type of family : Joint Nuclear

I. Details about family background

S.No.	Name of the family members	Relation ship to the head of the family	Age in years	Educational status	Occu- pation	Income per month in Rs.

II. General details on biogas plant:

1. Type of biogas plant installed:
2. Capacity of the plant: cu.m.
3. Year of construction:
4. Source of information:
5. Reasons for constructing the biogas plant.

6. Number of cattles possessed:

III. Details on Location of the plant:

1. Type of subsoil in which the plant was constructed

2. Space occupied by the plant - sq.m.

3. Distance of the plant to cowshed - metres

4. Distance of the plant to kitchen - metres

IV. Construction and operation details:

1. Mention the source from where technical guidance was obtained?

2. Number of days taken for construction.

3. Cost of construction for plant.

Materials	Quantity	Cost in Rs.
Masonry Materials		
Brick		
Cement		
Sand		
Accessory materials		
Iron bars		
Pipes		
Gate Valve		
Labour charges		
Cost of the biogas stove		

4. Length of the pipeline .... mts.

5. Give the total quantity of cowdung needed for initial loading of the plant. ... kg.

6. Where did you get the cowdung?

   a. From your own cattle

   b. Purchased from outside

7. When do the production of the gas was obtained after initial loading?

V. Financial Assistance:

   1. Mention the source of finance obtained for the construction of the plant

      a. Savings

      b. Loan from

         i) National Bank

         ii) Land development bank

         iii) Co-operative bank

         iv) Others

   2. What are the prerequisites to get the loan?

   3. Mention the amount of loan received ... Rs.

   4. Rate of interest

   5. Mode of repayment

   6. Subsidy received for construction

VI Biogas stove used in the kitchen:

VII. Details about operation:

1. Quantum of cowdung used daily ..... kg.

2. The proportion of cowdung and water used for daily feeding

3. Person incharge for feeding the gas plant?

   a) Head of the family

   b) Any one member in the family

   c) Servants

   d) Others

4. Time of feeding:

   Morning

   Evening

   Morning and Evening

5. Frequency of feeding

   a) Daily

   b) Alternate days

   c) Once in 3 days

   d) Others (specify)

6. How do you know the amount of gas produced?

   a) From the height of the flame

   b) From the level of the slurry in the slurry tank.

7. Do you add other types of waste in addition to the cowdung?

Yes

No

If yes, mention the different types of waste used and quantity?

VIII. Utilization of Biogas:

1. Do you get sufficient gas for cooking?

Yes

No

2. How many hours you are using the gas for a day?

Activities	No.of hours/day
i. Cooking	
Breakfast	
Lunch	
Tea	
Dinner	
ii. Lighting	
iii. Heating water for bathing purposes	
iv. Operating engines	
v. Any other (specify)	

IX. Care of maintenance:

1. Do you undertake the following?

   a. Feeding regularly.

   b. Checking and removing the accumulated water the gas pipeline.

   c. Checking the safety valve.

   d. Mixing cowdung and water in the proportion

   e. Checking the outlet of the slurry.

   f. Mixing cowdung and water thoroughly.

   g. Removing the stalks from the slurry.

   h. Cleaning the burner and burner top frequently.

   i. Keeping the regulator closed.

   j. Keeping the mixing and outlet tank closed.

   k. Any other.

X. Details regarding the benefits of Biogas:

APPENDIX VIII

EVALUATION SHEET USED FOR SOLAR COOKER

I. Name of the head of the family :

Type of family :

Number of members:

Adults :

Children :

Occupation of the Head of the family :

Total income of the family :

Education of the Head of the family :

Education of the Home-maker :

II. Details regarding use:

1. Place of keeping the solar cooker: : Front yard
   Back yard
   Any other place

2. Person helping to bring the solar cooker outside:

3. Items prepared in the solar cooker

S.No.	Item prepared	Qty. in grams	Time taken to prepare	Remarks of the cooked product

4. Items which are not liked by the home maker cooked by using the solar cooker.

Item not preferred	Reason

5. Number of days the solar cooker is used in every month.

January

February

March

April

May

June

6. Benefits of using the solar cooker.

7. Limitations in using the solar cooker.

APPENDIX IX

DATA SHEET USED BY THE HOMEMAKER TO RECORD THE FUEL AND TIME CONSUMPTION IN COOKING

S.No.	Menu followed	Items cooked	No. of persons for food being cooked	Utensils used	Fuel consumed			Time taken for cooking	Time taken for cleaning
					Initial quantity	Remaining quantity	Fuel used		

APPENDIX X

FUEL CONSUMPTION IN ORDINARY Vs SMOKELESS CHULAHS WHEN TWO MEALS ARE COOKED

S.No.	No.of members		In ordinary chulah in kg.	In smokeless chulah in kg.	Difference in kg.
1	2		2.63	2.07	0.56
2			2.67	2.13	0.54
		Mean	2.65	2.10	0.55
3	3		2.80	2.07	0.73
4			3.11	2.67	0.44
5			2.92	2.23	0.69
6			2.99	2.53	0.46
		Mean	2.96	2.38	0.58
7	4		3.650	3.30	0.349
8			4.131	3.410	0.721
9			4.136	3.450	0.686
10			3.580	3.094	0.484
11			3.578	3.093	0.485
		Mean	3.82	3.27	0.55
12	5		4.400	3.745	0.655
13			4.332	3.920	0.412
14			4.600	4.280	0.320
15			4.332	3.810	0.522
16			4.421	3.690	0.731
		Mean	4.42	3.89	0.53
17	6		5.431	4.912	0.499
18			5.380	4.878	0.482
19			5.460	4.907	0.533
20			5.451	4.985	0.446
21			5.450	4.868	0.662
		Mean	5.43	4.91	0.52

S.No.	No. of members		In ordinary chulah in kg.	In smokeless chulah in kg	Difference in kg.
22	7		5.749	5.338	0.411
23			5.732	5.327	0.405
24			5.673	5.298	0.375
		Mean	5.72	5.32	0.40
25	8		6.08	5.675	0.405
26			6.16	5.725	0.435
		Mean	6.12	5.70	0.42

FUEL CONSUMPTION IN ORDINARY Vs SMOKELESS CHULAH WHEN THREE MEALS ARE COOKED

S.No.	No.of members	In ordinary chulah in kg.	In smokeless chulah in kg.	Difference in kg.
1	2	2.90	2.22	0.68
2		3.138	2.63	0.508
3		3.352	3.03	0.322
	Mean	3.13	2.63	0.50
4	3	3.650	2.856	0.794
5		3.960	3.500	0.460
6		4.112	3.432	0.680
7		4.280	3.927	0.353
8		4.431	4.212	0.219
	Mean	4.09	3.59	0.50
9	4	4.539	4.107	0.432
10		4.400	3.980	0.420
11		4.190	3.695	0.495
12		4.421	3.879	0.542
13		4.450	3.809	0.641
	Mean	4.4	3.89	0.51
14	5	5.112	4.643	0.469
15		5.233	4.713	0.520
16		5.250	4.756	0.494
17		5.430	4.920	0.510
18		5.250	4.833	0.417
19		4.593	4.331	0.262
	Mean	5.14	4.7	0.43
20	6	5.640	5.137	0.503
21		5.626	5.212	0.414
22		5.638	5.128	0.510
	Mean	5.63	5.16	0.47
23	7	5.94	5.36	0.580
24		6.00	5.48	0.520
	Mean	5.97	5.42	0.55